

CONNECTICUT RIVER FLOOD CONTROL

ST. JOHNSBURY

LOCAL PROTECTION

PASSUMPSIC AND SLEEPERS RIVERS
VERMONT

DETAILED PROJECT REPORT

(ADVANCE DRAFT)



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

JANUARY 1967

32



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

IN REPLY REFER TO:

NEDED-E

31 January 1967

SUBJECT: Advance Draft - Detailed Project Report for St. Johnsbury
Local Protection, Passumpsic and Sleepers Rivers, Connecti-
cut River Basin, St. Johnsbury, Vermont

TO: Chief of Engineers
ATTN: ENGCW-P

1. In accordance with ER 1165-2-12 dated 1 April 1965, there are submitted herewith, for review and approval, advance draft copies of the Detailed Project Report, St. Johnsbury Local Protection, Passumpsic and Sleepers Rivers, St. Johnsbury, Vermont.

2. Appendix A contains initial letters from the Town of St. Johnsbury which indicate an intention to meet the requirements for local cooperation. Formal assurances of participation will be obtained pending approval and authorization of final designs for the project.

3. Plans and specifications will be prepared substantially in accordance with this report as approved. Funds in the amount of \$41,000 for preparation of plans and specifications and in the amount of \$878,000 for construction will be required. Construction funds will be requested upon completion of plans and specifications and the receipt of bids for construction.

FOR THE DIVISION ENGINEER:

JOHN Wm. LESLIE
Chief, Engineering Division

Incl (10 cys)
Advance Draft of
Det. Proj. Rpt.

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ST. JOHNSBURY, VERMONT

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NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASSACHUSETTS

JANUARY 1967

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ST. JOHNSBURY
LOCAL PROTECTION PROJECT
PASSUMPSIC AND SLEEPERS RIVERS
CONNECTICUT RIVER BASIN
ST. JOHNSBURY, VERMONT
JANUARY 1967

A. PERTINENT DATA

- | | |
|-------------------------------|---|
| 1. <u>Purpose</u> | Ice-jam flood protection and over-bank flood control of the Passumpsic and Sleepers Rivers. |
| 2. <u>Location</u> | Passumpsic and Sleepers Rivers, Town of St. Johnsbury, Caledonia County, Vermont. |
| 3. <u>Type of Improvement</u> | Earth dikes, concrete flood walls, railroad gate structure, pumping station and appurtenant structures. |
| 4. <u>Hydrology</u> | |
| Maximum flood of record | 42,500 c.f.s. |
| Project design flood | 42,000 c.f.s. |
| Drainage area | 428 square miles |
| 5. <u>Dike</u> | |
| Type | Earth-filled with stone slope protection to El. 553 and topsoil and seeded on riverside, topsoil and seeded on land side. |
| Length | 2,500 feet |
| Top elevation | 562.0 m.s.l. and 561 m.s.l. |
| Top width | 10 feet |
| Maximum height | 18 feet |
| Slopes, riverside | 1 on 3.0 |
| landside | 1 on 2.5 |

6. Walls
- | | |
|----------------|-----------------|
| Type | Concrete I-Wall |
| Length | 230 feet |
| Top elevation | 561 feet |
| Maximum height | 15 feet |
7. Gate Structure
- | | |
|--------|----------------------------|
| Type | Two steel swing gate leafs |
| Number | 1 |
| Size | 58 feet by 10 feet |
8. Sleepers River Relocation
- | | |
|-------------------|----------|
| Length | 500 feet |
| Width | 40 feet |
| Slopes, left bank | 1 on 3 |
| right bank | 1 on 2 |
9. Pumping Station
- | | |
|----------------------|---|
| Structure | Reinforced concrete with block and steel superstructure |
| Size | 15'-4" x 29'-4" |
| Pumps | 3 - Axial flow, 27 c.f.s., @ 17' head |
| Pumps, capacity each | 12,000 g.p.m. |
| Motors | Electric-driven |
| Sluice Gates | 1 - 54" x 54" hand operated |
10. Principal Quantities
- | | |
|-------------------------|-------------|
| Excavation | 37,200 c.y. |
| Earth Fill | 40,200 c.y. |
| Random Fill | 20,700 c.y. |
| Processed Sand | 2,300 c.y. |
| Processed Gravel | 5,000 c.y. |
| Gravel Bedding | 4,400 c.y. |
| Stone Protection | 8,500 c.y. |
| Topsoil & Seeding | 12,900 s.y. |
| Steel Bins | 1,650 s.f. |
| Reinforced Concrete | 1,000 c.y. |
| Steel Sheet Piling | 115 Tons |
| Wood Piling | 3,900 l.f. |
| Pumping Station | 1 Job |
| Railroad Gate Structure | 1 Job |
| Drainage Facilities | 1 Job |
| Access Road | 415 l.f. |

11. Cost Estimates

First Costs

Federal	\$919,000
Non-Federal	<u>61,000</u>
Total	\$980,000

Annual Costs

Federal	\$ 36,600
Non-Federal	<u>4,300</u>
Total	\$ 40,900

12. Benefits

Average Annual Benefits	\$ 47,000
Benefit-Cost Ratio	1.15 to 1.0

B. PROJECT AUTHORITY

This Detailed Project Report is submitted pursuant to authority contained in Section 205 of the 1948 Flood Control Act, as amended by Public Law 87-874 of the Flood Control Act of 1962 approved 23 October 1962. Further authority is contained in 1st Indorsement, dated 17 May 1965, from the Chief of Engineers to a report, dated 26 February 1965, from the Division Engineer, New England Division, Subject: "Supplemental Reconnaissance Report, Passumpsic and Sleepers Rivers, Saint Johnsbury, Vermont".

C. SCOPE OF DETAILED PROJECT REPORT

1. SCOPE

This Detailed Project Report reviews the general overbank flood problem along the Passumpsic River into an industrial area, known as the "Loop Area" in St. Johnsbury, Vermont. St. Johnsbury is susceptible to ice-jam floods caused by heavy rains in combination with snowmelt from the Passumpsic River attributed to several islands and channel obstructions in the Passumpsic River which, in turn, causes overbank flooding. The flood of record occurred in November 1927. This report submits a definite project plan of improvement which includes the construction of an earth dike, concrete flood wall, railroad gate structure, and a pumping station, located on the right bank of the Passumpsic River, from a point about 1200 feet downstream of the Portland Street bridge extending downstream to the confluence of the Sleepers River and thence upstream on the Sleepers River for a distance of about 500 feet to the railroad embankment.

2. TOPOGRAPHIC SURVEYS

A topographic survey of the proposed local protection project on a scale of 1" = 40' and a contour interval of 2 feet was made in August 1965 and June 1966.

3. SUBSURFACE EXPLORATIONS

Geological reconnaissance of the proposed project area has been made. Subsurface explorations were performed during November and December 1965 and June 1966 and consist of test borings, hand auger borings and test pits. The location and description are shown on Plates 3, 4 and 10. Investigations are delineated in detail in Appendix D.

4. ECONOMIC INVESTIGATIONS

A detailed flood damage survey was conducted in St. Johnsbury in 1964 to determine the extent of damage that would be experienced in a recurrence of 1927 flood stages. The survey consisted of a field examination of the project area and personal interviews with city and municipal officials and with property owners affected by flooding. Also, an investigation of economic developments and trends was made to project potential future growth and needs relevant to the project.

5. REAL ESTATE STUDIES

Real estate studies were made during September 1966. Local interests will procure all rights required in land. Present indications are that permanent easements for structures and channel improvement will be adequate. Real estate costs have been estimated to be \$36,000. Details of the studies are set forth in Appendix F.

6. CONFERENCES WITH LOCAL OFFICIALS

Close liaison has been maintained with town and state officials and other interested parties. Desires of local interests are described in Section O. A strong desire for construction and completion of the proposed project has been expressed. A letter of intent indicating the Town's willingness and ability to participate in the proposed improvement has been made available. Formal assurances will be furnished by the town and the State of Vermont prior to completion of final design.

D. PRIOR REPORTS

7. RECONNAISSANCE REPORT

In response to requests from the Governor of Vermont and local interests, and in compliance with ER 1165-2-12, a reconnaissance report on overbank and ice-jam flooding in St. Johnsbury, Vermont was made. The report stated that construction of dikes, railroad gate structures, pumping station, and the realignment of the Sleepers River would relieve the situation. The reconnaissance report indicated that the project was economically feasible and within the scope of Section 205, Public Law 87-874. It was recommended that the New England Division be authorized to prepare a Detailed Project Report. By 1st Indorsement dated 17 May 1965, the Chief of Engineers authorized preparation of a Detailed Project Report.

E. DESCRIPTION OF AREA

8. GEOGRAPHY

The Town of Saint Johnsbury, Vermont, is located about 180 miles north of Boston, Massachusetts, and about 75 miles east of Burlington,

Vermont, in the County of Caledonia. Having a population of about 9,000 (1960 census), it is situated on the Passumpsic River at the confluence of the Moose and Sleepers Rivers and at the intersection of U.S. Highway Nos. 2 and 5. The Passumpsic River is formed by the confluence of its East and West Branches in the Town of Lyndon, Vermont, and flows in a southwesterly direction to Lyndonville, Vermont. From this point, it follows a southerly course through Saint Johnsbury, about 9 miles to the Connecticut River at East Barnet, Vermont. A U.S.G.S. gaging station is located about 4 miles upstream from the confluence of the Connecticut River. The Passumpsic, with a drainage area of 507 square miles, has a length of about 43 miles and a fall of about 240 feet.

The Moose River which rises in the Town of East Haven, Vermont, flows in a southerly direction to Concord, Vermont, and then westerly to its confluence with the Passumpsic River at Saint Johnsbury. The Moose River has a length of about 31 miles and has a fall of about 1,200 feet with a drainage area of 126 square miles.

The Sleepers River rises in the Town of Danville, Vermont, and flows in a southeasterly direction to its confluence with the Passumpsic River in the southern part of Saint Johnsbury. It has a length of about 7 miles with a fall of about 385 feet and a drainage area of 47 square miles. It is also fed by several brooks and streams above the headwaters.

9. TOPOGRAPHY

Saint Johnsbury is located in the Upland Section of New England, a mature region of moderate relief which has been considerably modified by glaciation. The hills are generally rounded and thinly blanketed by till. The main valleys are relatively wide and are deeply filled with outwash and glacial lake deposits which form broad flood plains in the valley bottoms and extensive terraces along the valley sides. Where not masked by outwash and till, bedrock outcrops in the valley bottoms and along the lower flanks of the hills. On the upper slopes and tops of the hills, bedrock is exposed in numerous and extensive areas. Bedrock in the region consists of a series of closely folded crystalline rocks which are Paleozoic in age and include schist, quartzite, calcareous granulite, slate and amphibolite. The trend of the bedrock structure in the area is generally north-south.

10. SURFICIAL GEOLOGY

The Passumpsic River at the site flows along the eastern side of the valley with bedrock exposed along the highway above the river. West of the river a low, broad flood plain extends to the bottom of

the terrace on which the Town of Saint Johnsbury is largely built. Bedrock is deeply buried under the flood plain by thick and extensive glacial lake deposits consisting of stratified silts, sands and gravels overlain by recent alluvium, mainly silty sand with local areas of sandy silt. Artificial fills and low dikes composed of silty sand and gravelly, silty sand with some wood and trash have been constructed on the flood plain in the vicinity of the mouth of Sleepers River. Although bedrock occurs locally at shallow depths in the terrace on which the town is built, the terrace formed at least in part by a buried esker, is composed generally of thick and extensive deposits of stratified sands, silts and gravels.

11. MAIN RIVER AND TRIBUTARIES

a. Main river. The Passumpsic River originates in the mountains north of East Haven and flows southerly about 43 miles through the communities of Lyndonville, St. Johnsbury and Passumpsic. At Lyndonville, the West Branch of Passumpsic River enters from the north and Millers Run and South Wheelock Branch enters from the west resulting in a fan-shaped drainage pattern. The basin above this point has a length of 18 miles and a width of 13 miles. Except for the Moose and Sleepers Rivers, only minor tributaries enter the stream below this point. The Passumpsic River above the mouth of the Moose River is 30 miles long with an average fall of 35 to 40 feet per mile above Lyndonville and 12 feet per mile below Lyndonville. A large portion of the fall below Lyndonville occurs at existing dams. All tributaries, except Moose River, are short and steep, especially those in the lower part of the basin which have slopes of 70 to 80 feet per mile. About one half of the watershed is open pasture land and the remainder is largely wooded.

b. Tributaries. The Moose River rises in the Town of East Haven and flows in a southerly direction to the Village of Concord and then westerly to its confluence in St. Johnsbury. Except for a large meadow in East St. Johnsbury, the topography of the lower Moose River resembles that of the Passumpsic River.

The Sleepers River rises in the Town of Danville and flows in a southeasterly direction to its confluence with the Passumpsic River in the southern part of St. Johnsbury.

12. STREAM CHARACTERISTICS

Although the tributary slopes are steep along the rim of the watershed, numerous ponds and swampy areas provide large amounts of storage which reduce the rate of runoff.

The Moose River is very steep in the headwaters and practically all of the small tributary brooks similarly flow down mountain slopes. A large swamp in the approximate center of the watershed, with an area of about 1,000 acres, slows down the floodwaters from the upper half of the drainage area. This tends to desynchronize the peak flows from the upper part of the Moose and Passumpsic Rivers.

The Sleepers River is characterized by short, steep tributaries that contribute to rapid runoff. The elevations of the watershed varies from about 2,500 feet in the headwaters to 600 feet, msl, at the confluence.

13. MAPS

The Passumpsic River basin, including the site of the proposed local protection project, is shown on Department of Interior, U.S. Geological Survey maps indexed as St. Johnsbury, Lyndonville, Burke and Littleton quadrangles (scale 1:62,500). The Passumpsic River basin is shown on Plate No. 1 accompanying this report.

F. CLIMATOLOGY

14. GENERAL

The Passumpsic River basin has a variable climate characterized by frequent but short periods of heavy precipitation. It lies in the belt of the "prevailing westerlies" and consequently in the path of cyclonic disturbances that cross the country from west or southwest towards the east or northeast. The winters are moderately severe with subzero temperatures quite common, occurring on the average some 40 times each year. Summers are cool with temperatures averaging 60° to 70° Fahrenheit.

15. TEMPERATURE

The mean annual temperature at St. Johnsbury, Vermont is 44° Fahrenheit. Freezing temperatures can be expected between the latter part of September and early May. Monthly mean, maximum and minimum temperatures at St. Johnsbury are shown on Table 1.

16. PRECIPITATION

The average annual precipitation over the Passumpsic River watershed is approximately 40 inches. The maximum and minimum annual precipitation at St. Johnsbury are 48.64 and 27.15 inches, respectively. Table 1 shown the mean, maximum and minimum monthly precipitation at St. Johnsbury.

17. SNOWFALL AND SNOW COVER

The annual snowfall for the period of record at St. Johnsbury is about 79 inches. The mean monthly and annual snowfall for this station is shown on Table 2. Snow cover on the average reaches a maximum depth in late March or early April with water content normally ranging from 6 to 8 inches. Melting of the snow results in heavy spring runoff, but this cause alone seldom produces a damaging flood. However, the possibility of sudden thaws and heavy rains create a potential flood hazard every spring.

18. STORMS

The rapidly moving cyclonic storms or "lows" that travel over or near the Passumpsic River basin from the west or southwest toward the east or northeast produce frequent periods of unsettled but not severe weather. The region is also exposed to occasional coastal storms, some of tropical origin, that travel up the Atlantic coast and move inland over New England. The most severe general storms are those that develop along a slow moving (or stationary) air mass boundary (or front) that separate warm humid air to the south and east from colder dry air to the north or west. In addition, local thunderstorms can cause serious flash floods on the smaller streams.

G. RUNOFF AND STREAMFLOW DATA

19. DISCHARGE RECORDS.

The geographical locations and summary of pertinent data at each of 4 U.S. Geological Survey gaging stations located in the Passumpsic River basin are shown on Plate 1 and tabulated in Table 3.

20. RUNOFF

The average annual runoff for the period of record for the Passumpsic River at Passumpsic, Vermont is 724 cfs. The maximum, minimum and mean monthly runoff for this station is shown in Table 4.

TABLE 1

MONTHLY TEMPERATURE AND PRECIPITATION

ST. JOHNSBURY, VERMONT
(Elevation 699 feet, msl)

<u>Month</u>	<u>Temperature</u> (Degrees Fahrenheit) 71 Years of Record			<u>Precipitation</u> (Inches) 71 Years of Record		
	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
January	16.4	63	-38	2.32	5.06	0.67
February	18.1	60	-43	2.10	4.73	0.52
March	29.1	82	-27	2.51	6.76	0.30
April	42.5	89	0	2.66	6.15	0.49
May	55.1	94	20	3.01	6.56	0.04
June	64.4	101	30	3.47	8.05	0.66
July	69.1	101	36	3.65	7.56	0.96
August	66.2	100	33	3.54	7.86	1.09
September	58.8	95	22	3.43	8.11	0.68
October	47.9	92	12	2.93	8.07	0.29
November	35.1	77	-13	2.95	9.34	0.59
December	21.1	63	-43	2.46	5.12	0.95
ANNUAL	43.7	101	-43	35.03	48.64	27.15

TABLE 2

MEAN MONTHLY SNOWFALL
ST. JOHNSBURY, VERMONT
(Elevation 699 feet, msl)

69 Years of Record

Average Depth in Inches

<u>Month</u>	<u>Snowfall</u>
January	20.1
February	19.0
March	13.4
April	4.2
May	-1
June	0
July	0
August	0
September	T
October	0.6
November	6.7
December	15.0
ANNUAL	79.1

TABLE 3

STREAMFLOW RECORDSTHROUGH WATER YEAR 1965

<u>Location</u>	<u>Drainage Area</u>	<u>Period of Record</u>	<u>Discharge (cfs)</u>		
			<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
Moose River at Victory, Vermont	75.2	1947-1965	136	2,940	3.7*
Moose River at St. Johnsbury, Vermont	128	1928-1965	217	5,800	6.2*
East Branch Passumpsic River near East Haven, Vermont	53.8	1939-1945 1948-1965	100	2,200	13 *
Passumpsic River at Passumpsic, Vermont	436	1928-1965	713	16,000	13 **

*Instantaneous discharge

**Daily discharge

TABLE 4

MONTHLY RUNOFFPASSUMPSIC RIVER AT PASSUMPSIC, VERMONT

35 Years of Record

Discharge in Cubic Feet per Second

<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
January	465	1000	129
February	334	632	126
March	832	4010	159
April	2360	3920	1288
May	1370	3820	517
June	640	1442	277
July	370	892	136
August	268	730	121
September	328	1122	98
October	484	1520	132
November	683	1665	246
December	544	1260	170
ANNUAL	724	954	500

H. FLOODS OF RECORD

21. NOTABLE FLOODS

a. General. The Passumpsic River basin has experienced two major floods during the past 40 years; however, higher river stages resulting from ice jams have occurred on the average of about every two years. The potential for ice jam formation is present every year. Hydrologic studies indicate that major floods in the Passumpsic River basin may result from rainfall alone or from rainfall in combination with snowmelt. Ice jamming at sharp bends, islands and other restrictions in the rivers may further contribute to the destructiveness of winter and spring floods.

b. Recent floods. The floods of November 1927 and March 1936 are typical of the two types of major flood development in the Passumpsic River basin. The record flood of November 1927 was produced by intense rainfall associated with a low pressure system which traveled northward along the Atlantic coast. The estimated peak discharge at the site of the Passumpsic gage was 42,500 cfs, equivalent to about 98 cfs per square mile. The flood caused extensive damage, at which time the floors of buildings in the "loop" district of St. Johnsbury were flooded 5 to 7 feet deep. The March 1936 flood, with a peak discharge of 16,000 cfs at the Passumpsic gage, was produced by heavy rainfall with minor contribution from snowmelt. Most of the ice cover was cleared from the rivers by the high flows of the previous week.

An ice-jam flood in February 1938 reached a reported stage of 5 inches below the high water of 1936. A similar ice-jam flood in the spring of 1947 caused about the same level of flooding as that experienced in February 1938. An early spring that combined with a rain-storm on the 4th and 5th of March 1964 resulted in a serious flood threat to the St. Johnsbury area. High water levels in the "loop" area were produced by runoff and jamming of ice at the narrows downstream. Local interests have used dynamite to move and break up the ice jams, but have met with only limited success.

Records from the U.S. Geological Survey gaging stations on the Moose River at Victory and St. Johnsbury, the East Branch, Passumpsic River near East Haven, and the Passumpsic River at Passumpsic for the periods of record are summarized in Table 5.

c. Effect of ice. During the spring breakup, water levels at numerous locations along the rivers in the basin are elevated by the erratic downstream movement of the ice floe. Ice jams form temporarily in the main river channel at many locations due to the sharp bends and

other constrictions; however, the most critical locations are in the St. Johnsbury area. The downstream movement of the ice floe is often halted at the "narrows", located below the confluence of the Sleepers River, due to the combined effects of the channel alignment, the railroad bridge, and also the power pool and dam immediately downstream of the railroad bridge. The amount of increase in stage at the loop is dependent upon the quantity and distribution of flows in the Passumpsic, Moose and Sleepers Rivers, the structure or soundness of the ice cover and timing of the breakup. It is estimated that ice jams at the "narrows" cause a general rise in water levels of 1 to 3 feet. The effect of ice jamming is believed negligible whenever the total discharge exceeds about 25,000 cfs.

I. FLOOD FREQUENCY

The frequency or percent chance of occurrence of peak discharges on the Passumpsic River at the U.S. Geological Survey gaging station, drainage area 436 square miles, was determined by the methods outlined in ER 1110-2-1450, dated 10 October 1962. Discharge-frequency curves for selected locations in the Passumpsic River basin are shown on Plate C-2. The stage-frequency relationships for the loop area, drainage area 428 square miles, was determined by drainage area adjustment and stage-discharge data for the narrows. The resulting discharge and stage-frequency data for the loop area, including estimated average ice effects, are shown in Table 6.

TABLE 5

RECORDED FLOODS - PASSUMPSIC RIVER BASIN

	<u>Moose River</u>		<u>East Branch</u>	<u>Passumpsic</u>
	<u>At Victory</u> DA - 75.2	<u>At Saint Johnsbury</u> DA - 128	<u>Passumpsic River near East Haven</u> DA - 53.8	<u>River at Passumpsic</u> DA - 436
<u>Period of Record</u>	1947 - 65	1929 - 65	1940 - 65	1929 - 65
<u>Date</u>	<u>Peak Discharge (in cfs)</u>			
November 1927	-	-	6,800 est.	42,500 est.
April 1929	-	5,800	-	6,080
April 1933	-	4,670	-	9,660
April 1934	-	5,660	-	8,550
March 1936	-	4,780	2,600 est.	16,000
March 1938	-	-	-	11,000 est.
September 1938	-	2,030	1,570 est.	7,710
May 1940	-	2,970	2,180	9,660
April 1947	2,080	3,160	-	7,950
April 1950	2,940	4,700	1,970	10,700
June 1952	2,380	3,140	1,790	9,670
March 1953	2,720	4,400	1,380	8,610
April 1954	2,860	4,140	2,000	10,900
April 1955	2,620	3,760	1,440	9,140
November 1959	2,780	3,430	2,080	9,080
April 1960	2,670	3,400	2,200	8,630
March 1964	-	-	-	5,000 est.

TABLE 6

FREQUENCY DATAPASSUMPSIC RIVER AT

ST. JOHNSBURY, VERMONT (LOOP AREA)
 (DA = 428 square miles)

<u>Frequency</u> (% Chance of Occurrence)	<u>Discharge</u> (cfs)	<u>Elevation (feet msl)</u>			
		<u>Natural</u>	<u>Natural W/Ice</u>	<u>Modified by Victory Reservoir</u>	<u>Mod. by Victory W/Ice</u>
0.5	42,300	558.2	558.2	557.9	557.9
1.0	33,400	556.8	556.8	556.7	556.7
2.0	26,300	555.6	555.6	555.4	555.4
5.0	19,200	554.1	554.3	553.8	554.1
10.0	14,900	553.0	553.4	552.7	553.2
20.0	11,300	552.0	552.6	551.5	552.4
30.0	9,400	551.3	552.2	550.9	552.0
40.0	8,100	550.8	551.9	550.4	551.7
50.0	7,600	550.3	551.6	550.0	551.4

J. STANDARD PROJECT FLOOD

22. GENERAL

The standard project flood for the Passumpsic and Sleepers Rivers at St. Johnsbury was developed from standard project storm rainfall as described in EM 1110-2-1411. Unit hydrographs were derived from analysis of recorded floods in the basin. Plate C-4 shows the adopted unit hydrographs and flood hydrographs for the Passumpsic and Sleepers Rivers standard project flood.

23. STANDARD PROJECT STORM

The standard project storm was centered over the Passumpsic River basin. Grades for walls and dikes were predicated on the most adverse combinations of concurrent discharges from the standard project flood on the Passumpsic and Sleepers Rivers. The standard project storm volume for the 48-hour period totaled 9.50 inches. Losses of 0.10 inch per hour were deducted from the rainfall resulting in 6.25 inches of runoff excess.

24. UNIT HYDROGRAPHS

A hydrologic review of the Passumpsic River basin has resulted in the adoption of the unit hydrographs based on those developed during previous design studies for Victory Reservoir. A 3-hour unit hydrograph was also computed from observed data at the U.S. Department of Agriculture gaging station on the Sleepers River at North Danville (DA = 42.9 square miles). These unit hydrographs were combined and a compound 3-hour unit hydrograph was developed for the total drainage area above the narrows at St. Johnsbury. The resulting unit hydrograph had a peak ordinate of 9,440 cfs, equivalent to 22 csm and is shown on plate C-4.

25. STANDARD PROJECT FLOOD DISCHARGE

The standard project flood hydrograph was derived by applying the standard project storm rainfall excess to the adopted unit hydrograph. The resultant flood hydrograph at St. Johnsbury below the Sleepers River has a peak ordinate of 59,000 cfs which is 40 percent greater than the record flood of November 1927. The hydrograph for the standard project flood in the Sleepers and Passumpsic Rivers at St. Johnsbury are shown on Plate C-4.

K. PROJECT DESIGN FLOOD

26. GENERAL

The record flood of November 1927 has been selected as the project design flood for the St. Johnsbury local protection project.

This flood has a natural peak flow of 42,500 cfs in the Passumpsic River at St. Johnsbury below the Sleepers River. It is estimated that at the time of the natural peak flow of 13,500 cfs on the Sleepers River, the total concurrent discharge in the Passumpsic River was 35,000 cfs. These represent the most critical combination of concurrent discharges.

The authorized Victory Reservoir, to be located on the upper Moose River, would reduce the project design flood in the Passumpsic River to 42,000 cfs. Due to the large amount of natural valley storage in the upper Moose River, runoff from the area above Victory Dam does not contribute substantially to peak flow on the Passumpsic River at the loop area. The following items were considered in adopting the November 1927 flood as the project design flood.

a. The frequency of the November 1927 flood is estimated to be 200 years, and the peak discharge is nearly three times as great as any other flood of record.

b. The physical and economic limitations of the project area precluded consideration of a larger design flood.

c. Damages within the protected area would be noncatastrophic and there would be little likelihood of loss of life in the event a greater flood overtopped the dikes and wall.

It was therefore concluded that the adoption of the November 1927 flood as the project design flood will provide a relatively high degree of protection to the "loop" area of St. Johnsbury.

L. FLOOD DAMAGE AND ECONOMIC DEVELOPMENT

27. EXTENT AND CHARACTER OF FLOODED AREA

Over 45 acres of built-over land lying along the right bank of the Passumpsic River at and above its confluence with the Sleepers River are susceptible to flooding by high water stages in the river. High water stages in this section of St. Johnsbury, called the "Loop Area," can be caused by ice jams, an almost annual event; by large rainstorms with rapid run-off, or by a combination of the two. The record flood in this area with depths of 5 to 7 feet of water in the buildings was in November of 1927 and was attributable solely to run-off from a large storm. A lesser flood in March 1936 resulting from a combination of ice and high run-off caused stages about 4.5 feet lower than the record flood. Commercial and industrial properties, the town's recently constructed sewage treatment plant and the tracks of the Canadian Pacific Railroad, all located here, are susceptible to damage from flood waters. Some 200 people are employed in the area.

28. FLOOD DAMAGES

The record flood of 1927 caused losses estimated at \$46,000 at St. Johnsbury in the Loop areas. At that time only two enterprises were located in the area, a plumbing supply house and a lumber yard. Since then the Loop has been almost completely built over and a recurrence of the record 1927 flood under 1966 conditions would cause losses estimated at \$545,000 in the same area.

29. AVERAGE ANNUAL LOSSES

Estimated flood losses at various stages of flooding were combined with stage-frequency data to derive annual losses. Annual losses, so derived, amount to \$49,600 at 1966 price level.

30. TRENDS OF DEVELOPMENT

St. Johnsbury, the county seat of Caledonia County, is the financial and commercial center for a large portion of northeastern Vermont. Its economy, based on a combination of manufacturing and service industries is a stable one with no definite short term trends. The stability of the economy is expected to continue without too much change over the next 50 years. The activity in the project area should continue at its current level over this period. Because of the present high utilization of the area there is little opportunity for substantial growth over the period.

31. AVERAGE ANNUAL BENEFITS

Tangible average annual flood damage prevention benefits were derived as the difference in annual losses most likely to be expected in the project area without the project and the annual losses remaining after the project is constructed. Average annual benefits so derived amount to \$40,000 with the project as next added after the construction of Victory Dam and Reservoir, the only other flood control project affecting the "Loop" area.

Construction of the project will obviate the need for the almost annual blasting of ice jams (in some years there are 2 or more) and relieve the community of the cost thereof. The average annual costs of such blasting are estimated by local officials to amount to \$7,000.

Total tangible primary benefits to the project amount to \$47,000 annually.

In addition to the tangible benefits noted above the construction of the project would contribute to the economy of the St. Johnsbury area by utilizing unemployed or under-employed local labor. At the time of the Reconnaissance Report, St. Johnsbury was designated a "Redevelopment Area" as part of Caledonia County by the Economic

Development Administration under P.L. 89-136. Improved economic conditions in a portion of the county have resulted in a change in its designation to Title I in June of 1966 so that presently it is ineligible for redevelopment benefits. However, an increase in unemployment in the area could well place the area once more in the Title IV group and it would be possible to realize "Redevelopment Benefits." Such benefits are presently estimated to amount to \$4,700 annually.

M. EXISTING CORPS OF ENGINEERS FLOOD CONTROL PROJECTS

There are no existing Corps of Engineers flood control projects on the Passumpsic and Sleepers Rivers. Restudies are in progress for the Victory Dam and Reservoir, an authorized multiple-purpose dam on the Moose River. The Public Works Appropriation Bill for Fiscal Year 1964 provided funds for the prosecution of the restudy. The purpose of this study is to determine if reclassification of the project from a "deferred" to an "active" category is warranted.

N. IMPROVEMENTS OF FEDERAL AND NON-FEDERAL AGENCIES

There are no Federal or non-Federal improvements within the watershed of the Passumpsic and Sleepers Rivers.

O. IMPROVEMENTS DESIRED

Several meetings have been held with local interests to determine the attitude of townspeople and local officials towards the proposed plan of flood control. The citizens and manufacturers of the town are desirous of preventing future losses to the industries along the Passumpsic River and feel that the proposed plan, as outlined herein, will adequately reduce future damage potential. Local interests have expressed a willingness to fully cooperate on this proposal for flood protection. Letters of concurrence and comment from local interests are included in Appendix A of this report.

P. FLOOD PROBLEM AND SOLUTIONS CONSIDERED

32. FLOOD PROBLEM

The problem is one of ice-jam flooding and general overflow of the Passumpsic River into the "Loop Area" of St. Johnsbury. The flood of record occurred in November 1927 and was produced by intense rainfall associated with a low pressure system which traveled northward along the Atlantic coast. The flood had an estimated peak discharge of 42,500 c.f.s. at the site of the Passumpsic Gage. The primary flood problem on the Passumpsic River was caused principally by ice-jams.

Records from the U.S. Geological Survey gaging stations on the Moose River at Victory and St. Johnsbury, the East Branch Passumpsic River near East Haven, and the Passumpsic River at Passumpsic for the periods of record are summarized in Table 5.

33. SOLUTIONS CONSIDERED

Consideration has been given to protection against ice jams and river flooding for areas along the Passumpsic and Sleepers Rivers. The existing topography of the Sleepers River is such as to hold ice jams upstream of the principal damage area along the River; namely, the Fairbanks-Morse Company which is the keystone to the Town's economy. However, a considerable flood problem does exist on the Sleepers River. Consideration has been given to the construction of a multi-purpose dam and reservoir referred to as the Fish Hatchery Dam. The dam would be located about 3 miles upstream of the confluence of the Sleepers and Passumpsic Rivers. The dam, which could provide flood control storage, water supply, and recreation would cost approximately \$3,000,000. Owing to the scope of the project exceeding the \$1,000,000 Federal limitation of Public Law 87-874 (Section 205), reporting for this project has been referred to the Comprehensive Basin Studies of the Connecticut River which are currently underway. It is anticipated that a Basin Report will be submitted in the Spring or Fall of 1969.

Plans of protection from both ice and river flooding have also been considered for the following reaches of the Passumpsic River: (a) the St. Johnsbury Center area above the Vermont Public Service Company Dam along both banks of the river extending upstream for a distance of about 7 miles; (b) from the Bay Street dam just south of Portland Street Bridge upstream to the Vermont Public Service Company Dam at both banks of the Passumpsic River extending a distance of about 0.8 miles and including those areas along the Moose River adjacent to confluence with Passumpsic River; and, (c) Bay Street Dam area downstream to Dam #3 including the "loop area" along both banks of the river extending for a distance of about 1.5 miles.

Of the areas listed above, only the "loop area" was found to have sufficient concentration of losses to support a local protection type improvement. In the other areas studied, although losses were found to be significant, they were spread over large reaches and in most cases local type protection would incur extensive property taking. Those upstream areas not conducive to local type protection improvements will be reviewed under the comprehensive Connecticut River Basin Studies with a view to providing upstream reservoirs.

Accordingly, this report concerns itself only with a plan of protection for the "loop area" of St. Johnsbury situated along the right bank immediately downstream of the remains of the Bay Street Dam, which is complete within itself.

Q. PROPOSED IMPROVEMENT

34. GENERAL DESCRIPTION

The project provides for the construction of an earth dike, I-type concrete flood walls, railroad gate structure, pumping station and the realignment of about 500 feet of the Sleepers River. A general layout of the recommended plan for flood protection in St. Johnsbury is shown on Plate No. 2.

35. EARTH DIKE

This feature of the work provides for the construction of an earth dike with a top width of 10 feet and a top elevation, including 3 feet of freeboard, of 562 feet above m.s.l. and sloping to elevation 561 at the Sleepers River. The dike will extend from a point about 1200 feet downstream of the Portland Street Bridge to the embankment of the Purina Company then skip for about 700 feet of the embankment starting again and proceeding downstream to the confluence of the Sleepers River, and thence upstream on the Sleepers River for about 200 feet along the right bank. The embankment at the Purina Company will be improved on the riverside to meet the standard of the riverside slope of the dike. The dike is composed of compacted impervious and random fill. The riverside slope consists of two feet of rock slope protection on one foot of gravel bedding to elevation 553, and a six-inch layer of seeded topsoil to the top of dike. On the landside slope, stone protection is placed at the toe of slope to an elevation three feet above existing grade and then a 12-inch layer of topsoil and seeding is placed to elevation 556, and a six-inch layer of seeded topsoil to the top of the dike. The riverside slope will be 1 vertical on 3 horizontal. The landside slope will be 1 vertical on 2.5 horizontal.

36. I-WALL

The concrete I-wall will extend about 200 feet along the Sleepers River adjacent to the Sewage Treatment Plant, from the earth dike to the railroad gate structure. On the upstream side of the railroad gate structure, a short section of I-wall, about 30 feet long, will extend to high ground. The concrete I-wall will have a maximum projection above ground on the riverside of 10 feet and on the landside a 2-foot berm and 8 feet of projection. The I-wall will cap a steel sheet piling wall having at least a 27-foot penetration.

37. RAILROAD GATE STRUCTURE

The railroad gate structure has a clear opening of 58'-0" with top of gate at elevation 563 and top of concrete sill at elevation 554.67. The structure will have a concrete base slab 75 feet by 24 feet by 4 feet thick and will tie into the I-wall at each end. The gate will consist of 2 steel gate leafs with an A-frame support on each leaf. The top of the concrete abutment housing the gate will be at elevation 564.0 with the top of gate 1'-0" below. The actual gate leaf height will be about 8'-2" which permits clearance over the three railroad track rails of 2 inches. The bottom of the base slab will be supported on battered wood piles.

38. PUMPING STATION

A pumping station for handling the interior drainage, seepage and industrial waste will be located on the landside of the dike adjacent to the Sewage Treatment Plant. The structure will house three axial flow pumps, each capable of handling 27 c.f.s at 17-foot static head. The pumps will be driven by vertical electric motors. Pumps will discharge over the dike. Each discharge will be equipped with a flap valve at the river end and a vent and vacuum breaker at the top of the dike. Runoff will normally flow by gravity through a conduit at one end of the station. The conduit will have a sluice gate on the riverside of the dike. The station sump will normally be kept dry. During flood periods the gravity conduit gate will be closed and gates to the station sump opened. The station will be unheated. Dehumidification equipment will be provided to control condensation on walls and equipment.

Electric drive for the pump motors has been chosen since electric drive is more economical than engine drive and electric service is considered sufficiently reliable. The Central Vermont Public Service Corporation's 3,750 kva substation in St. Johnsbury is fed by a 33 kv overhead transmission line and a 12.5 kv overhead circuit from the 700 kw, No. 3 hydro generating station nearby. This area is not subject to hurricane winds at the time of flooding; the flooding being the result of spring runoff and/or heavy rains. Consequently, the lines being overhead are not a serious liability. The utility company has a history of only short unscheduled outages. These would not seriously affect the operation of the pumping station.

39. DRAINAGE

a. General. Local runoff, in the area of the protection, flows generally in a west to east direction into the Passumpsic River. In addition to overland flow, there is also a combined drain (sanitary

wastes and storm drainage) which passes through the area, by means of a pressure conduit, and discharges at the Sewage Treatment Plant. Here the flow in the pipes is either treated or discharged directly to the Passumpsic River depending on the amount of flow. When the existing pressure conduit is cleaned, by flushing with fire hoses, the flow is discharged directly to the Passumpsic River.

b. Proposed. The overland flow, which would normally discharge into the Passumpsic River, will be trapped behind the proposed dike. This will necessitate installing a gravity flow storm drain, behind the dike, to a point of discharge at the new pumping station. Drains have been sized on the basis of a 10-year storm (100-year for outfall) and sufficient slope has been maintained to prevent surcharging in the pipes for the design storm. Manholes and inlets have been located to prevent any buildup of water behind the dike and to permit future connections to the drain, by the town, if and when desired.

Flow through the drain will normally be by gravity but when high river is experienced the gravity outfall drain will be closed. This will be done by means of the flap gate and by manually closing the sluice gate which will be provided for this purpose. With the gates closed the flow will then be pumped over the dike and into the river.

c. Revisions to existing drains. The existing pressure conduits, which carry both sanitary and storm wastes, pass beneath the dike in three places as shown on Plates Nos. 3 and 4. At each crossing the pipe will be reinforced and a valve manhole will be provided to permit diversion of the flow into the river during high water. If the flow is not diverted it will increase the size of the pumps in the pumping station since sanitary sewage and drainage flow, from outside the protected area, would flow to the pumping station in the pressure conduits and would have to be pumped along with the drainage flow from behind the dike.

The existing 24-inch outfall from the Sewage Treatment Plant will be reinforced under the dike and will be provided with a gate valve to permit closing during high river stages to prevent backflow into the Sewage Treatment Plant.

At the intersection of Routes 2 and 5, northwest of the Sewage Treatment Plant, an existing 24-inch drain which presently drains 14 acres into the protected area will be plugged and a new drain will be installed to divert this flow outside the protection.

Near the north end of the Purina Company Building there is an existing sewer which presently discharges raw sewage from the Purina Building directly into the Passumpsic River. The town has been made aware of this condition and it is assumed that this will be corrected, by the town before the dike is installed.

d. Toe drain. A perforated pipe drain will be installed, along the Passumpsic River, at the landside toe of slope of the dike. Toe drain will discharge into the new interior storm drain.

40. RELOCATION OF UTILITIES

The plan of improvement will not require the relocation of utilities. There are no changes contemplated for existing sewer, water or other drainage lines. The dike crosses the 14" pressure sewer in two locations and the 24" pressure sewer in one. The pressure sewers will be inclosed in concrete at the crossings.

R. MULTIPLE-PURPOSE FEATURE

The St. Johnsbury Local Protection Project has no multiple-purpose features and is designed for ice-jam flood protection only.

S. RECREATION DEVELOPMENT

The plan of improvement offers no recreational features.

T. REAL ESTATE REQUIREMENTS

The acquisition of land for the St. Johnsbury Local Flood Protection Project will be the responsibility of local interests. There are no highway or cemetery relocations involved in the project. The total area to be acquired consists of 8 acres of permanent easement or fee taking and 7 acres of temporary easements. Appendix F incorporates the details of real estate requirements and estimated costs.

U. ESTIMATES OF FIRST COSTS AND ANNUAL CHARGES

41. GENERAL

The estimates of Federal and non-Federal first costs and annual charges are given in Table 7, and have been prepared on the basis that local interests would bear the cost of relocation and alteration to existing utilities; furnish all lands, water rights and rights-of-way necessary for the project construction; and operate and maintain the project after completion. Unit prices based on average bid prices for similar work in the general area are based on 1966 price levels, and include minor items of work which are not separately detailed.

42. BASIS OF COST ESTIMATES

Detailed cost estimates have been made upon the basis of a design which would provide an economical and safe structure. Estimates of

quantities are based on neat outlines of the proposed designs and foundation requirements. Costs were computed as outlined in the Corps of Engineers Engineering Manual 1120-2-104.

43. CONTINGENCIES, ENGINEERING, SUPERVISION AND ADMINISTRATION

Estimates of construction costs have been increased by 15 percent to cover contingencies. The cost of engineering and design has been taken as 14.5 percent of the construction costs. The cost of supervision and administration has been taken as 6.3 percent of the combined construction and engineering costs.

44. BASIS OF ANNUAL CHARGES

Annual charges are based on a project life of 50 years. Federal annual charges include 3.125 percent of the total investment for interest and 0.854 percent for amortization. Non-Federal annual charges include 3.125 percent for interest and 0.854 percent for amortization plus maintenance, operation and replacement costs which are based on the particular site conditions and previous experience with similar projects.

TABLE 7

ESTIMATES OF FIRST COSTS AND ANNUAL CHARGES
LOCAL PROTECTION, ST. JOHNSBURY, VERMONT

FIRST COST
(1966 Base)

Item No.	Description	Estimated Quantity	Unit	Unit Price	Estimated Amount
<u>FEDERAL COST</u>					
1.	<u>Site Preparation</u>	1	Job	L.S.	\$ 7,500
2.	<u>Stream Control</u>	1	Job	L.S.	3,000
3.	<u>Earth Dike</u>				
	✓ Excavation, unclassified	29,800	CY	1.25	37,250
	✓ Compacted Impervious Fill	30,700	CY	2.00	61,400
	✓ Compacted Pervious Fill	4,700	CY	2.00	9,400
	✓ Uncompacted Pervious Fill	2,300	CY	1.50	3,450
	✓ Compacted Random Fill	19,400	CY	1.75	33,950
	✓ Dumped Random Fill	1,300	CY	1.50	1,950
	✓ Processed Sand	2,300	CY	4.00	9,200
	✓ Compacted Processed Gravel	4,400	CY	4.00	17,600
	✓ Gravel Bedding	3,800	CY	3.00	11,400
	Stone Protection:				
	Class I	800	CY	8.00	6,400
	Class II	4,700	CY	7.50	35,250
	Class III	1,100	CY	7.50	8,250
	Topsoil & Seeding 6"	9,200	SY	1.00	9,200
	Topsoil & Seeding 12"	3,700	SY	1.50	5,550
	Steel Bins	1,170	SF	5.25	6,140
					\$ 266,890
	Sub-total Earth Dike				
4.	<u>Concrete I Wall</u>				
	Excavation, unclassified	5,600	CY	1.25	7,000
	✓ Compacted Impervious Fill	1,400	CY	2.00	2,800
	✓ Uncompacted Processed Gravel	600	CY	3.00	1,800

TABLE 7 (Continued)

ST. JOHNSBURY VERMONT - LOCAL PROTECTION

Item No.	Description	Estimated Quantity	Unit	Unit Price	Estimated Amount
	✓ Gravel Bedding	600	CY	3.00	1,800
	✓ Stone Bedding	300	CY	4.00	1,200
	✓ Stone Protection - Class IV	1,600	CY	7.50	12,000
	Concrete	260	CY	60.00	15,600
	Sheet Piling	115	Tons	300.00	34,500
	Steel Bins	480	SF	5.25	<u>2,520</u>
	Sub-total Concrete I-Wall				\$ <u>79,220</u>
5.	<u>Access Road</u>				
	Gravel Base	300	CY	2.00	600
	Double Bit. Sur- face Treat.	800	SY	1.00	800
	Guard Rail	500	LF	3.00	<u>1,500</u>
	Sub-total Access Road				\$ <u>2,900</u>
6.	<u>Interior Drainage</u>				
	✓ Toe Drain Pipe Line	1	Job	L.S.	6,000
	Revisions to exist- ing pressure sewer line	1	Job	L.S.	15,200
	Divert Flow from Treatment Plant to Pumping Sta.	1	Job	L.S.	800
	Interior Drainage, Including Gravity Outfall from Pump Sta.	1	Job	L.S.	<u>120,000</u>
	Sub-total Interior Drainage				\$ <u>142,000</u>
7.	<u>Pumping Station</u>				
	Structural Excavation	400	CY	2.00	800
	Compacted Backfill	170	CY	6.00	1,020
	Concrete	133	CY	70.00	9,310
	Superstructure	1	Job	L.S.	38,000
	Electrical	1	Job	L.S.	16,000
	Mechanical	1	Job	L.S.	<u>55,000</u>
	Sub-total Pumping Station				\$ <u>120,130</u>

TABLE 7 (Continued)

ST. JOHNSBURY VERMONT - LOCAL PROTECTION

Item No.	Description	Estimated Quantity	Unit	Unit Price	Estimated Amount
8.	<u>Railroad Gate</u>				
	Structural Excav.	1,400	CY	2.00	2,800
	Compacted Backfill	900	CY	6.00	5,400
	Shoring	3,800	SF	1.25	4,750
	Wood Piling	3,900	LF	2.80	10,920
	Concrete	600	CY	70.00	42,000
	Steel Gates	16,000	lbs.	.55	8,800
	Railroad Traffic Control	1	Job	L.S.	30,000
	Sub-total Railroad Gate				\$ 104,670
				TOTAL	\$ 715,810
				Contingencies, 15%	107,190
				Total Construction Cost	\$ 823,000
				Engineering Design	41,000 (1)
				Supervision & Administration	55,000
				TOTAL ESTIMATED FEDERAL COST	\$ 919,000

(1) Does not include \$78,000 for pre-authorization studies

NON-FEDERAL COST

Lands and Damages	\$ 36,000
Diversion of drainage at So. Main St.	5,000
Relay existing outfall from sewage treatment plant	6,000
Encasement of existing pressure sewer pipes	<u>14,000</u>

TOTAL ESTIMATED NON-FEDERAL COST 61,000

TOTAL ESTIMATED PROJECT FIRST COST \$ 980,000

TABLE 7 (Continued)

ST. JOHNSBURY VERMONT - LOCAL PROTECTION

ANNUAL CHARGES

Federal

Interest (0.03125 x 919,000)	\$ 28,750
Amortization (0.00854 x 919,000)	<u>7,850</u>

Total Federal Annual Charges	\$ 36,600
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Non-Federal

Interest (0.3125 x 61,000)	\$ 1,900
Amortization (0.00854 x 61,000)	520
Maintenance and Operation	1,280
Major Replacement	<u>600</u>

Total Non-Federal Annual Charges	<u>4,300</u>
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TOTAL ANNUAL CHARGES	\$ 40,900
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V. ESTIMATES OF BENEFITS

Average annual flood damage prevention benefits, taken as the difference between average annual losses under existing conditions and those losses remaining after construction, amount to \$47,000. It is not anticipated that the project will result in any increased utilization or enhancement benefits. Details of the derivations of benefits are set forth in Appendix B.

W. COMPARISON OF BENEFITS AND COSTS

Average annual benefits for the St. Johnsbury Local Protection Project are estimated at \$47,000 and average annual costs are estimated at \$40,900. The resulting ratio of benefits to cost is 1.15 to 1.0.

X. PROJECT FORMULATION AND ECONOMIC JUSTIFICATION

The Division Engineer finds that past floods have caused substantial damages to the lands and existing structures along the Passumpsic River in St. Johnsbury. He concludes that a plan of improvement consisting of an earth dike, concrete flood walls, railroad gate structure, a pumping station and realignment of the Sleepers River would provide the maximum practicable degree of protection for this area against future ice-jam flooding. Project formulation resolved itself into one plan of protection which had not only economic justification but also afforded construction feasibility and compatibility with existing improvements in the area. Protection can be provided most suitably by the plan as submitted herein for approval.

Total project costs of the recommended plan are estimated at \$980,000 exclusive of pre-authorization costs of \$78,000, of which \$919,000 represents the Federal share and \$61,000 the non-Federal share. The plan of protection will yield average annual benefits of \$47,000 as against annual costs of \$40,900, producing a benefit-to-cost ratio of 1.15 to 1.0.

Y. SCHEDULES FOR DESIGN AND CONSTRUCTION

45. DESIGN

It is estimated that preparation of contract plans and specifications for the project will cost \$41,000 and can be completed in 6 months after approval of this report.

46. CONSTRUCTION

Construction of the project can be accomplished under a single contract during a 24-month period. Funds for the construction of the project would be requested upon evaluation of bids received.

Z. OPERATION AND MAINTENANCE

Maintenance of this project will be the responsibility of local interests. Periodic inspections will be made by the Corps to assure that adequate maintenance is performed in accordance with regulations prescribed by the Secretary of the Army. It is estimated that maintenance, operation and major replacements for the project will cost local interests \$1280 annually. An operation and maintenance manual will be provided to the Town of St. Johnsbury upon completion of the project.

AA. LOCAL COOPERATION

In accordance with Section 205 of Public Law 87-874, local interests are required to provide without cost to the United States, all lands, easements, rights-of-way, and utility relocations and alterations necessary for the construction and operation of the project, including disposal areas; hold and save the United States free from damages due to the construction work; and maintain and operate all the works after completion in accordance with existing regulations prescribed by the Secretary of the Army. Local interests would also be required to furnish the added assurance that they would contribute to the United States all necessary funds over and above the Federal cost limitation of \$1,000,000 should this become necessary. State and town officials have indicated a willingness to fulfill conditions of local cooperation. A letter from the Town Selectman which constitutes preliminary assurances is included in Appendix A of this report.

In areas where easement takings are not required for construction of project features, the Town of St. Johnsbury will establish ordinances to prevent further encroachment in the natural flood plain of the stream. The channel would be maintained and kept free of obstructions and debris by local interests. The restrictions in the flood plain, which is reserved for the passage of the design flood, will include the following: (1) no new construction of any type will be permitted, and (2) existing hazardous structures will be removed when obsolete.

BB. COORDINATION WITH OTHER AGENCIES

Plans for local protective works in St. Johnsbury have been reviewed by officials of the Town of St. Johnsbury and the State of Vermont. Statements have been received from the U.S. Department of Agriculture, Soils Conservation Service, U.S. Department of Health, Education and Welfare, U.S. Department of the Interior, Fish and Wildlife Service and are incorporated in Appendix A. The project has no effect on hydro-electric power generation, recreation, pollution abatement, fish migration or other collateral water resource uses.

CC. CONCLUSIONS

Investigations and studies for the local protection project covered by this report lead to the following conclusions:

a. The Town of St. Johnsbury faces the threat of heavy damages in future floods. A recurrence of the flood of record under 1966 conditions would cause damages of \$545,000.

b. Local interests desire protection for their principal industries to secure the economic base of the Town.

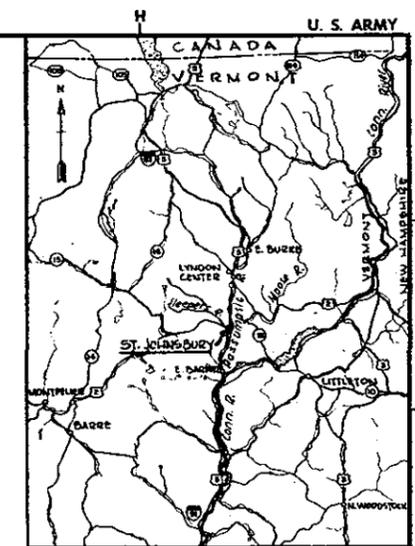
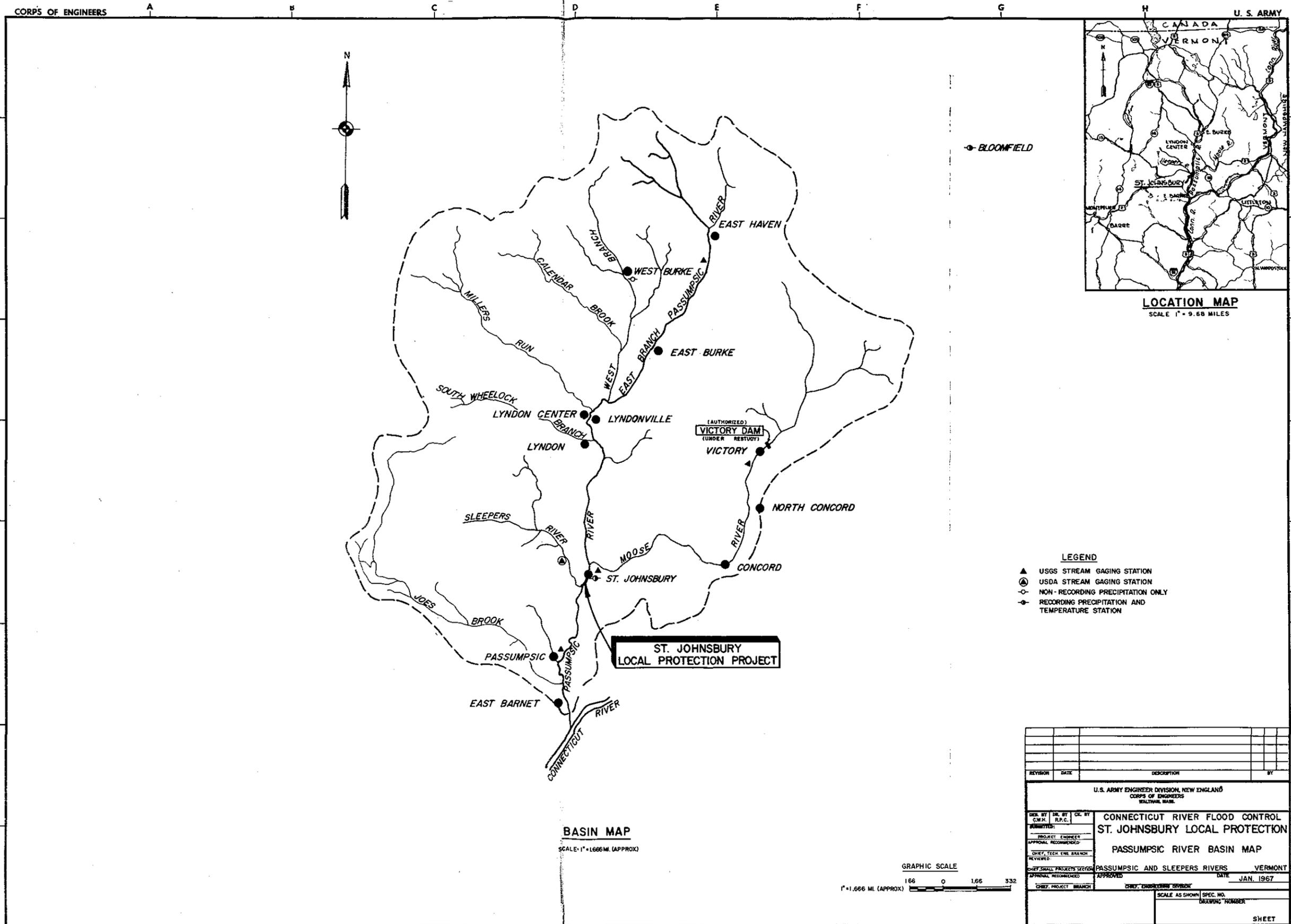
c. Protection can be provided most suitably by the proposed plan at a total estimated Federal first cost of \$919,000 and local cost of \$61,000.

d. The project is economically justified by the ratio of annual benefits to annual costs of 1.15 to 1.

e. The threat of recurring damaging ice-jam floods makes it desirable to construct the project as soon as possible.

DD. RECOMMENDATIONS

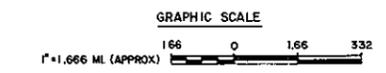
It is recommended that the project, as submitted in this report, be authorized by the Chief of Engineers under the provisions of the Flood Control Act of 1948, as amended, and that funds be allotted in the amount of \$41,000 for preparation of plans and specifications. Funds for construction will be requested upon receipt and analysis of bids for construction.



LOCATION MAP
SCALE 1" = 9.68 MILES

- LEGEND**
- ▲ USGS STREAM GAGING STATION
 - ▲ USDA STREAM GAGING STATION
 - NON-RECORDING PRECIPITATION ONLY
 - ⊖ RECORDING PRECIPITATION AND TEMPERATURE STATION

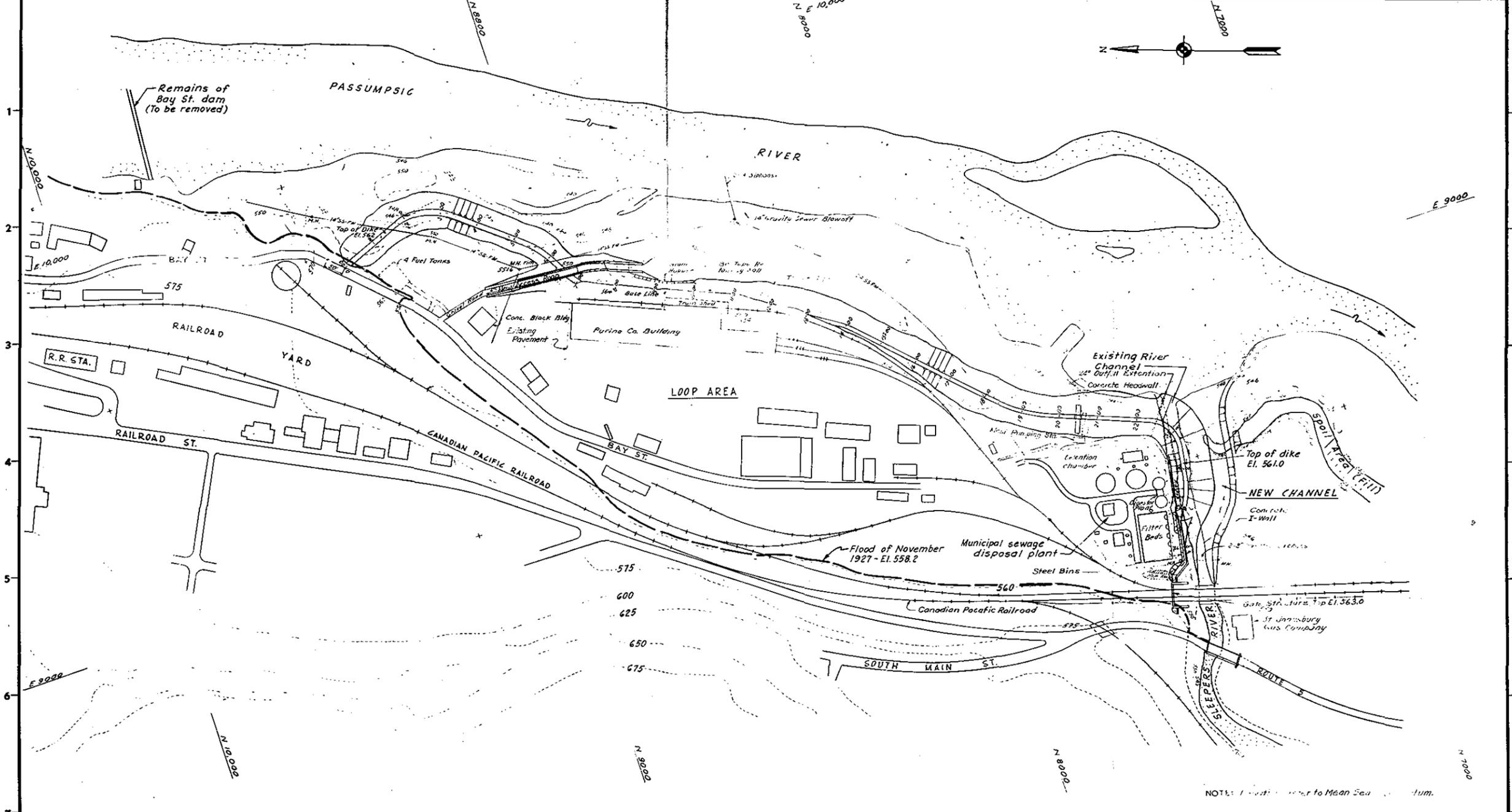
BASIN MAP
SCALE 1" = 1.666 MI. (APPROX)



REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY	DR. BY	CHK. BY	CONNECTICUT RIVER FLOOD CONTROL ST. JOHNSBURY LOCAL PROTECTION
SUBMITTED:	PROJECT ENGINEER	APPROVAL RECOMMENDED:	PASSUMPSIC AND SLEEPERS RIVERS VERMONT
CHIEF, TECH. ENG. BRANCH	REVIEWED:	CHIEF, SMALL PROJECTS SECTION	DATE
			JAN. 1967
CHIEF, PROJECT BRANCH	CHIEF, ENGINEERING DIVISION	APPROVED:	
		SCALE AS SHOWN	SPEC. NO.
		DRAWING NUMBER	
			SHEET

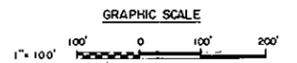


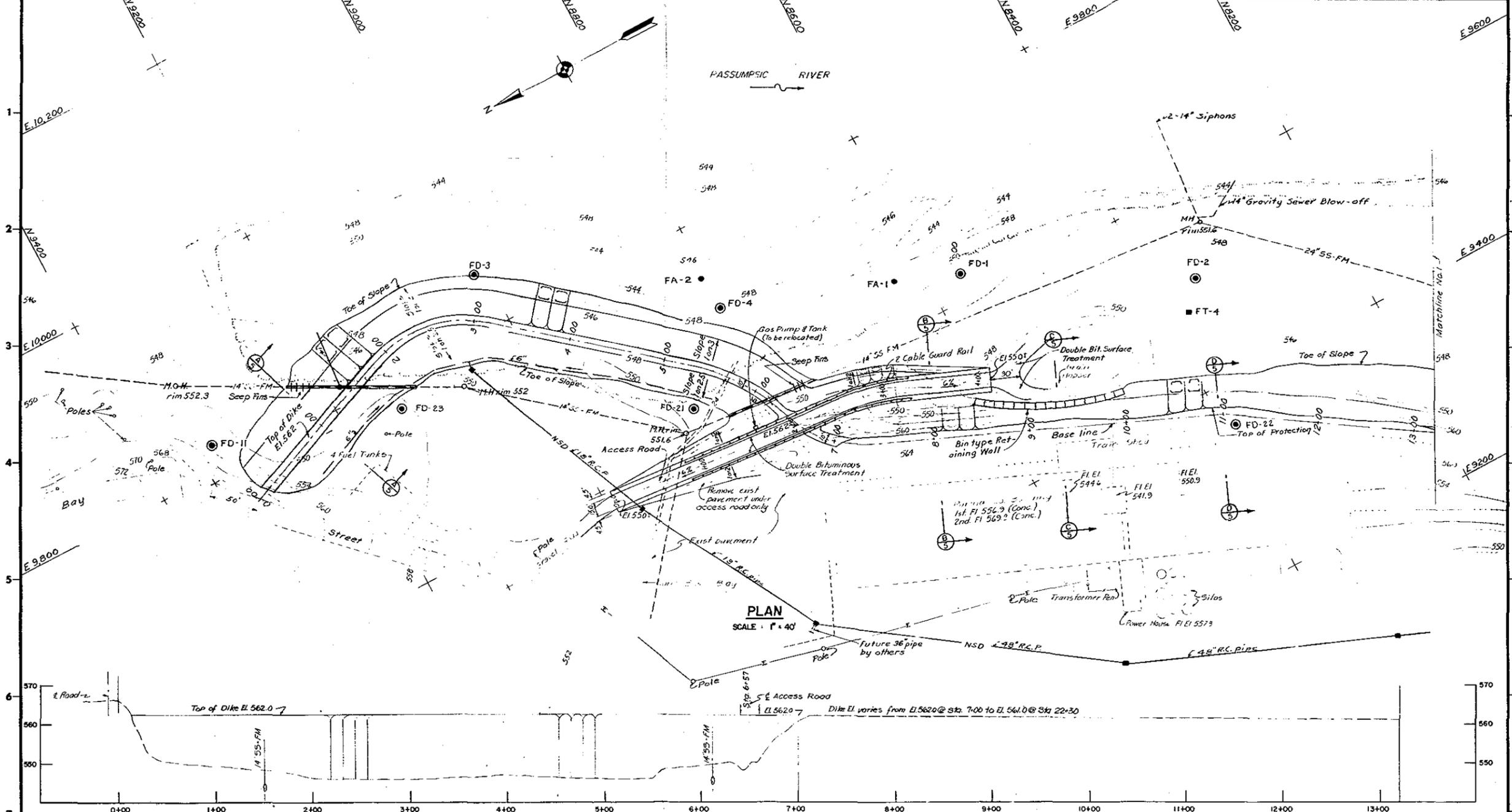
PROJECT PLAN
SCALE: 1" = 100'

NOTE: Elevation refers to Mean Sea Level.

REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.			
DESIGNED BY C.E. 152	DRAWN BY C.E. 152	CHECKED BY C.E. 152	DATE JAN 1967
PROJECT ENGINEER APPROVAL RECOMMENDED		CONNECTIONS AND SLEEPERS RIVERS VERMONT	
CHIEF, TECH. ENG. BRANCH REVIEWED		DATE	
CHIEF, SMALL PROJECTS SECTION APPROVAL RECOMMENDED		DATE	
CHIEF, PROJECT BRANCH		CHIEF, ENGINEERING DIVISION	
SCALE AS SHOWN SPEC. NO.		DRAWING NUMBER	
SHEET			



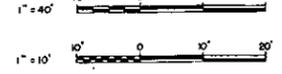


PLAN
SCALE: 1" = 40'

PROFILE OF DIKE

SCALE: HOR. 1" = 40'
VERT. 1" = 10'

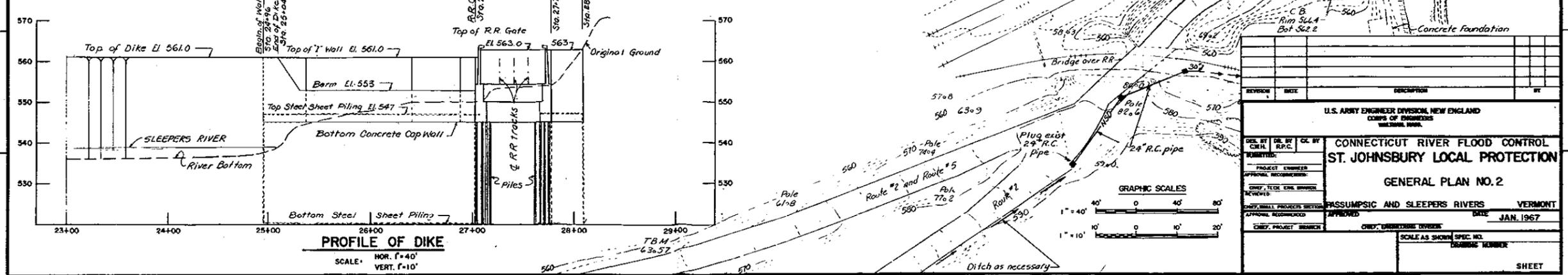
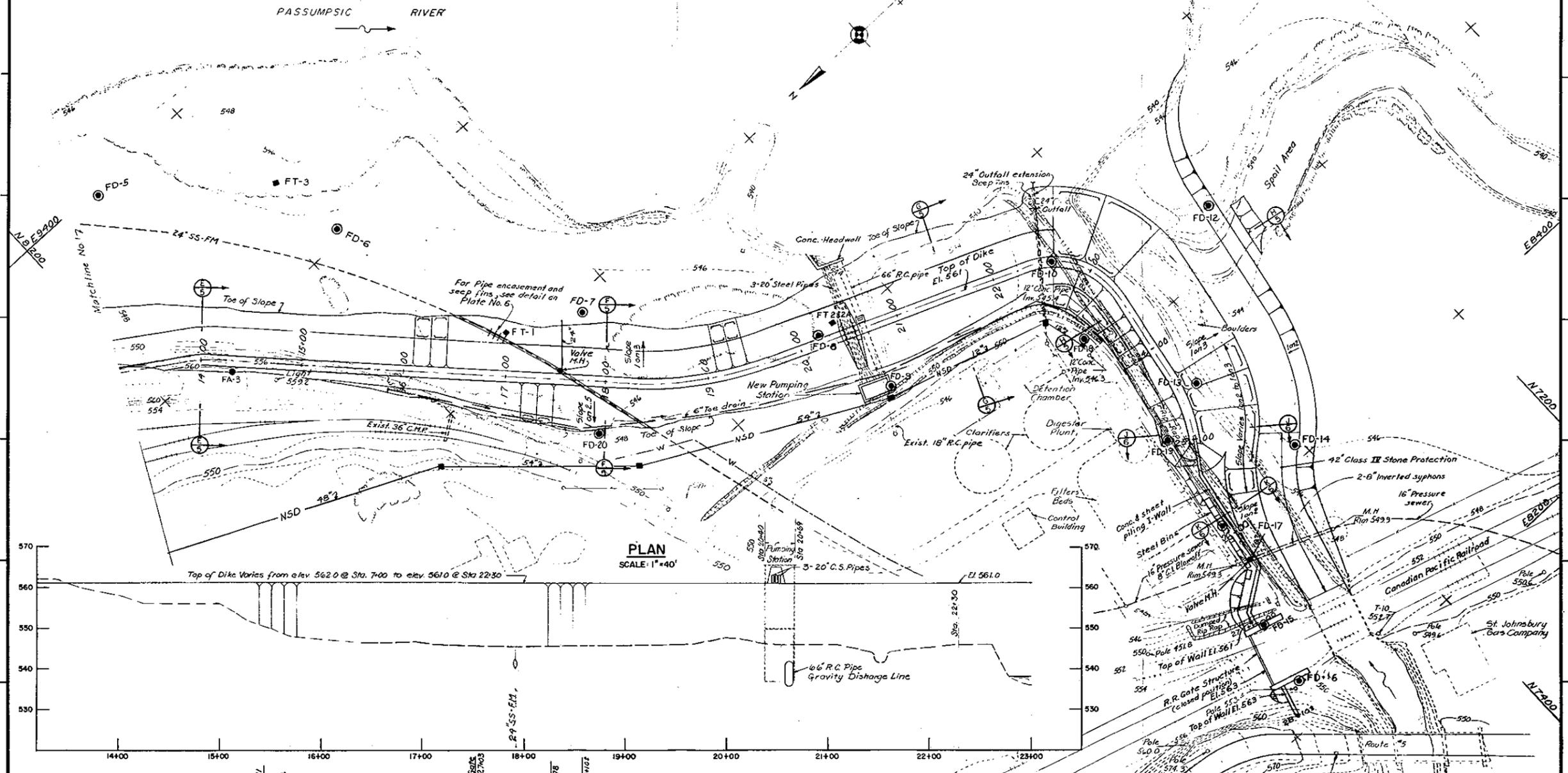
GRAPHIC SCALES



LEGEND		
NEW	EXISTING	DESCRIPTION
—NSD—	E	Electric Transmission Line
—	—	Storm Drain
—	—	Toe Drain
—	—	Drain Inlet
●	—	Gate Valve Manhole
—SS-FM—	—	Sanitary Sewer - Force Main
—W—	—	Water Line
○ FD	—	Foundation Test Boring
● FA	—	Foundation Hand Auger Boring
■ FT	—	Foundation Test Pit

NOTE: For logs of borings and test pits, see Plate No 10

REVISION	DATE	DESCRIPTION	BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.			
CONNECTICUT RIVER FLOOD CONTROL ST. JOHNSBURY LOCAL PROTECTION GENERAL PLAN NO. 1			
DES. BY: []		CHK. BY: []	
SUBMITTED: []		R.P.C. []	
APPROVAL REQUIRED:			
PROJECT ENGINEER		[]	
CHIEF, TECH. ENG. BRANCH			
REVIEWED: []			
CHIEF, SMALL PROJECTS SECTION		PASSUMPSIC AND SLEEPERS RIVERS VERMONT	
APPROVED: []		DATE: JAN. 1967	
CHIEF, PROJECT BRANCH		CHIEF, DESIGNING DIVISION	
SCALE: AS SHOWN		SPEC. NO.	
DRAWING NUMBER		SHEET	



REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WILBRIDGE, MASS.

CONNECTICUT RIVER FLOOD CONTROL
ST. JOHNSBURY LOCAL PROTECTION

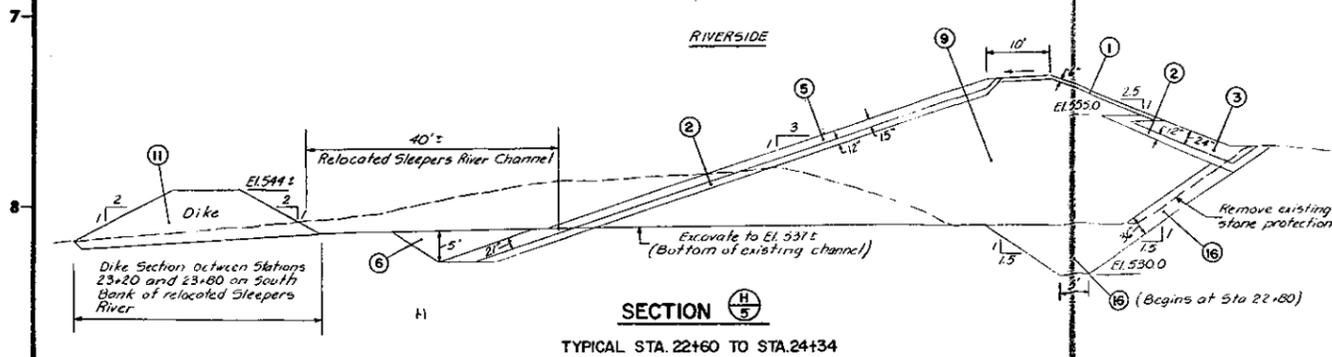
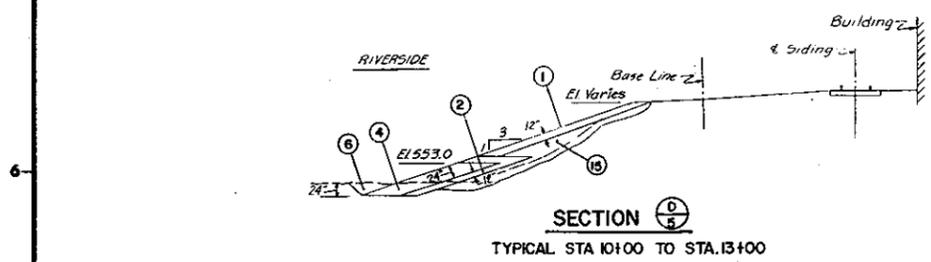
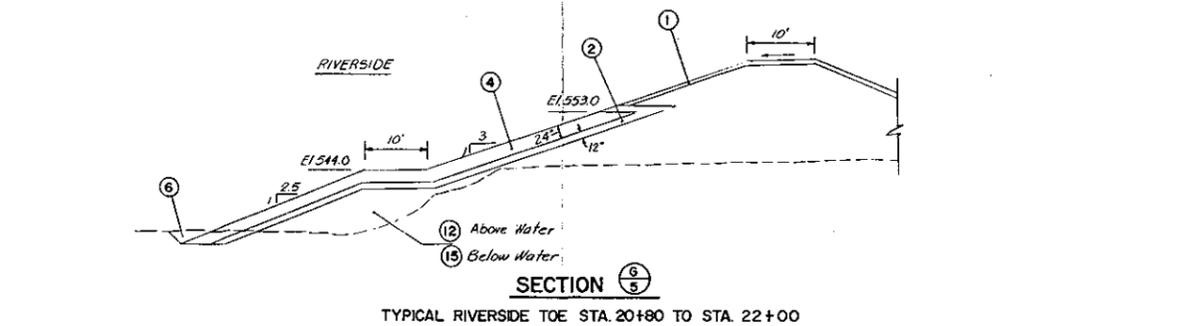
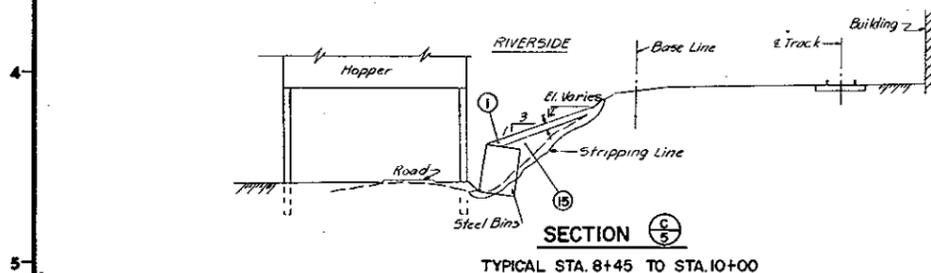
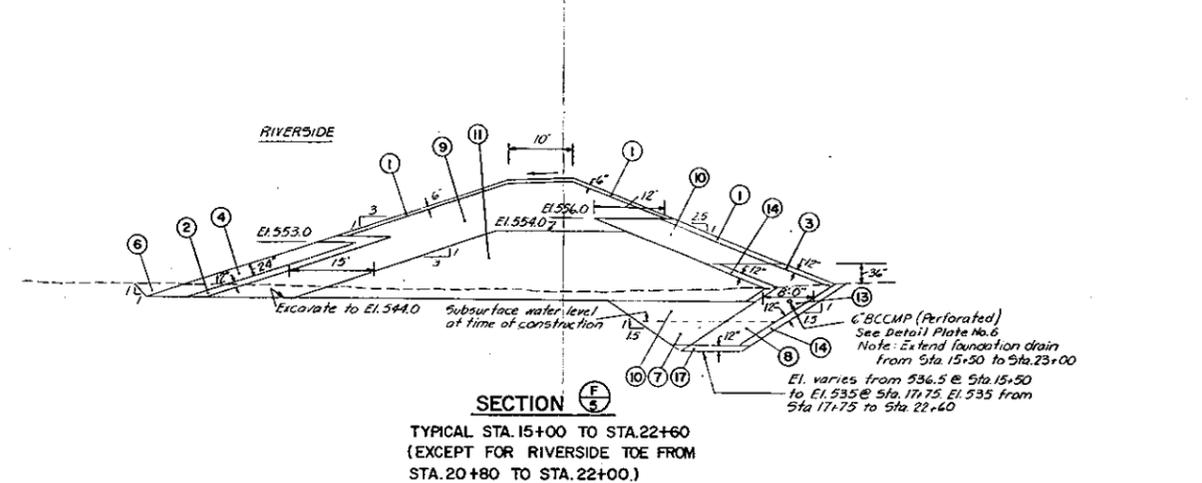
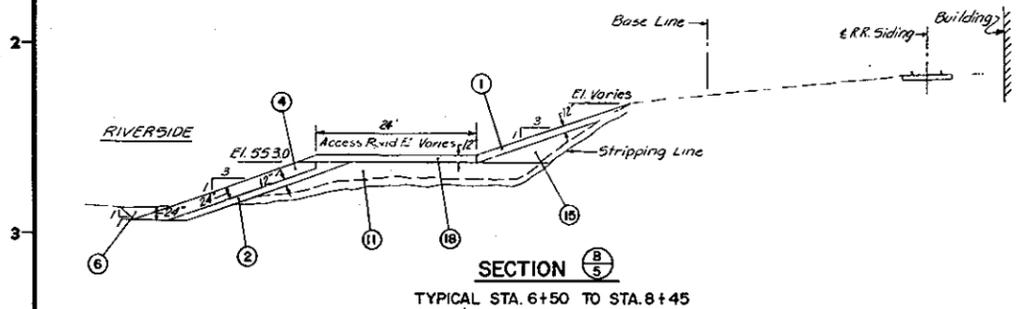
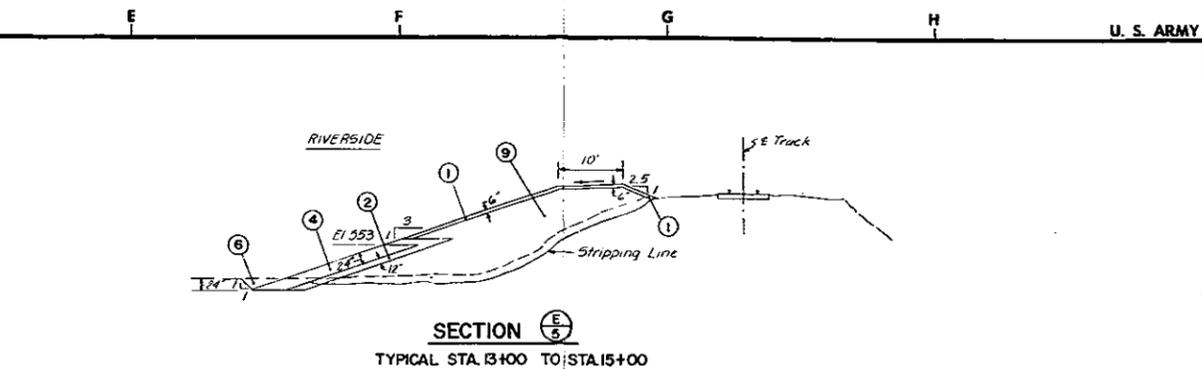
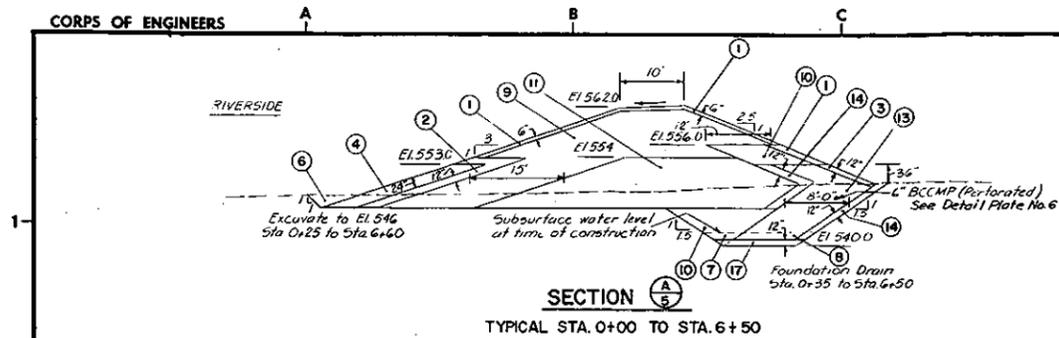
GENERAL PLAN NO. 2

PASSUMPSIC AND SLEEPERS RIVERS VERMONT

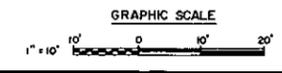
DATE: JAN. 1967

SCALE AS SHOWN SPEC. NO. 1000

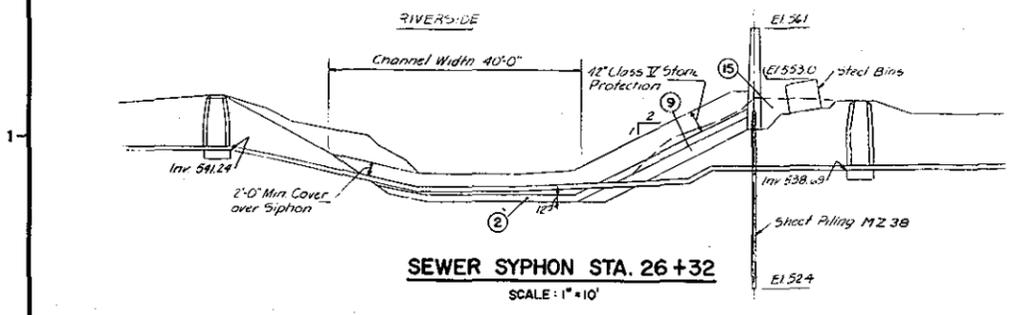
SHEET



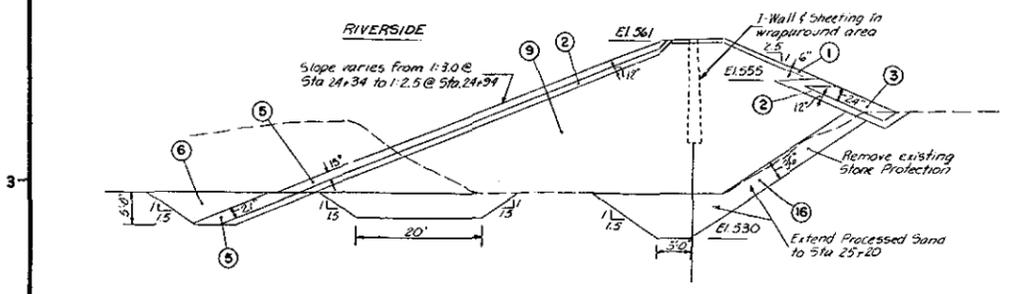
MATERIALS LEGEND	
NO.	TYPE
1	TOPSOIL SEEDED
2	GRAVEL BEDDING
3	CLASS I STONE PROTECTION
4	CLASS II STONE PROTECTION
5	CLASS III STONE PROTECTION
6	DUMPED RANDOM FILL
7	DUMPED PERVIOUS FILL
8	DUMPED PROCESSED GRAVEL
9	COMPACTED IMPERVIOUS FILL
10	COMPACTED PERVIOUS FILL
11	COMPACTED RANDOM FILL
12	COMPACTED GRAVEL FILL
13	COMPACTED PROCESSED GRAVEL
14	UNCOMPACTED PERVIOUS FILL
15	UNCOMPACTED GRAVEL FILL
16	UNCOMPACTED PROCESSED SAND
17	PROCESSED SAND
18	ROAD GRAVEL



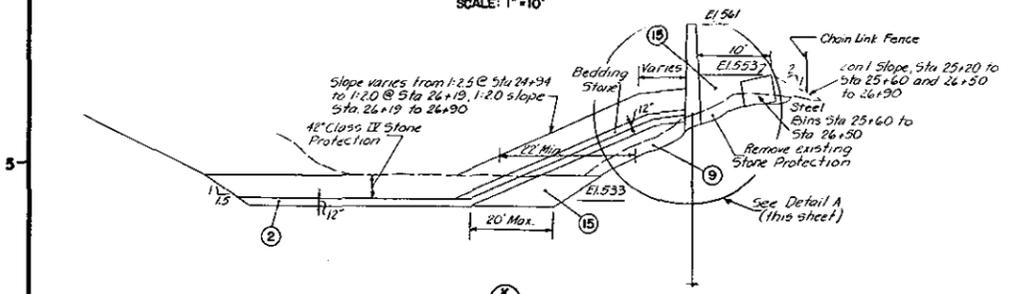
REVISION		DATE	DESCRIPTION	BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND CORPS OF ENGINEERS WALTON, MASS.				
CONNECTICUT RIVER FLOOD CONTROL ST. JOHNSBURY LOCAL PROTECTION				
SECTIONS				
DESIGNED BY C.W.H.		DRAWN BY R.P.C.		DATE JAN. 1967
SUBMITTED BY				
APPROVAL RECOMMENDED				
PROJECT ENGINEER				
CHIEF, TECH. ENG. BRANCH				
REVIEWED				
SUPERVISOR, PROJECTS SECTION				
APPROVED				
CHIEF, PROJECT BRANCH				
CHIEF, ENGINEERING DIVISION				
SCALE: 1" = 10'		SPEC. NO. DRAWING NUMBER		



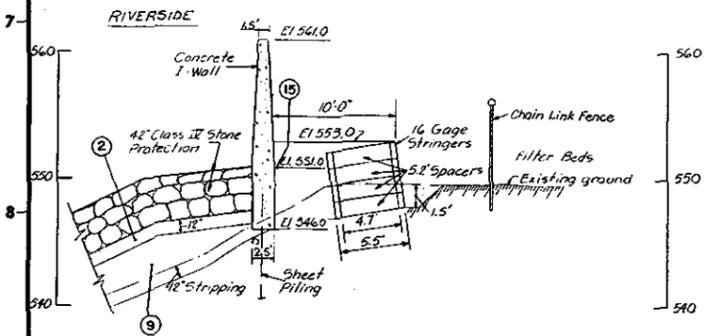
SEWER SYPHON STA. 26+32
SCALE: 1"=10'



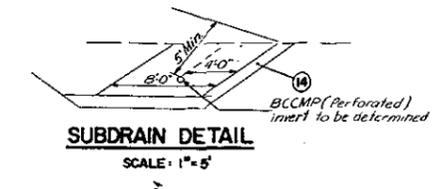
SECTION J-4
TYPICAL STA. 24+34 TO STA. 24+94
(EXCEPT AS NOTED)
SCALE: 1"=10'



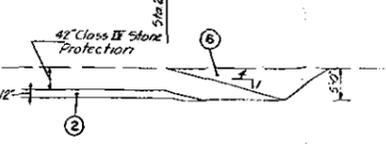
SECTION K-6
TYPICAL STA. 24+94 TO STA. 26+90 (BRIDGE)
EXCEPT AS NOTED (SEE DETAILS B & C)
SCALE: 1"=10'



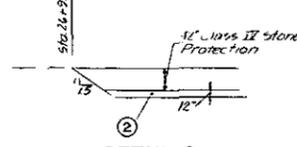
DETAIL A
SCALE: 1"=5'



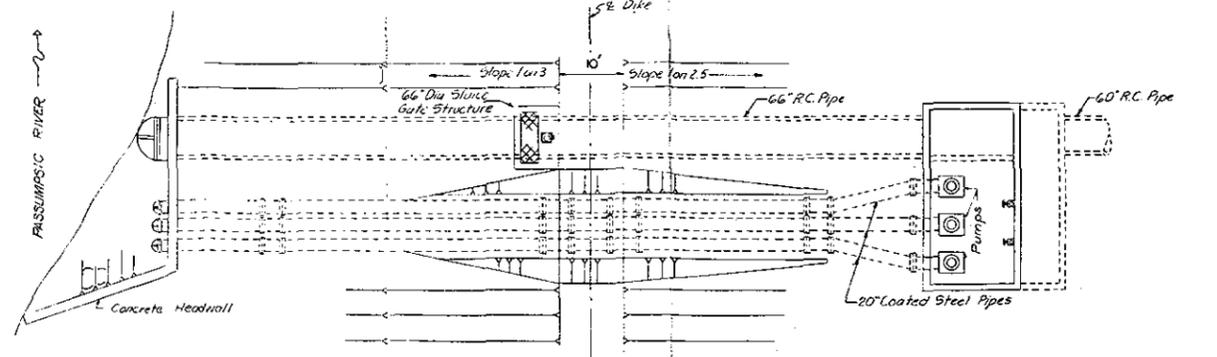
SUBDRAIN DETAIL
SCALE: 1"=5'



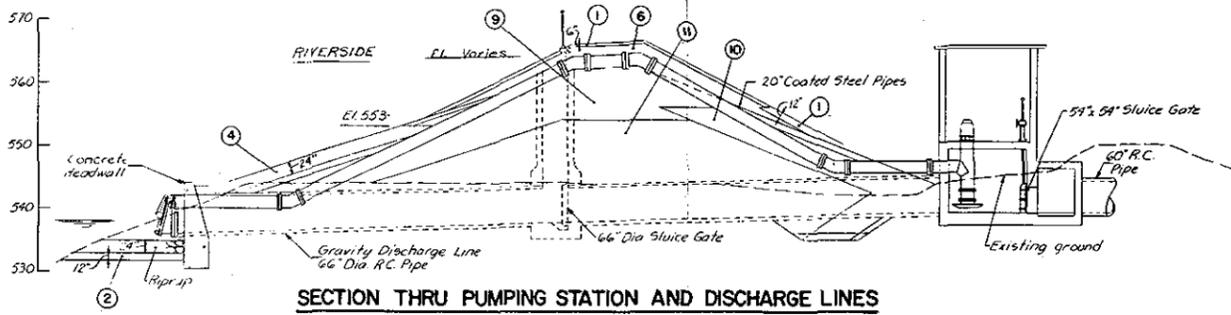
DETAIL B
END OF CHANNEL BOTTOM PROTECTION
AT DOWNSTREAM END
SCALE: 1"=10'



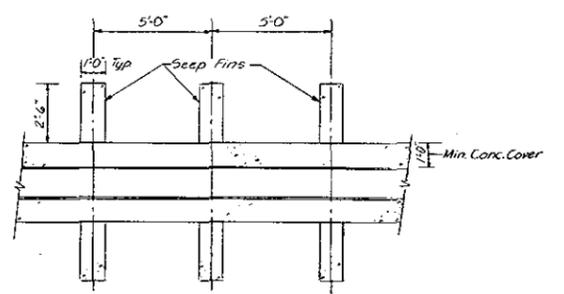
DETAIL C
END OF CHANNEL BOTTOM PROTECTION
AT UPSTREAM END
SCALE: 1"=10'



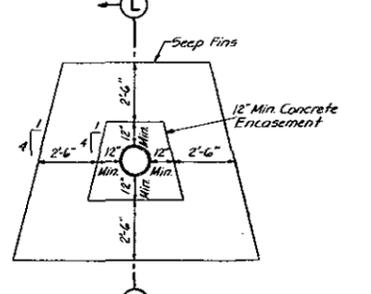
PLAN - PUMPING STATION
SCALE: 1"=10'



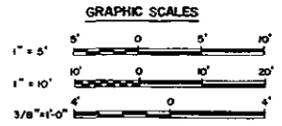
SECTION THRU PUMPING STATION AND DISCHARGE LINES
SCALE: 1"=10'



SECTION L-L
SCALE: 3/8"=1'-0"



SEEP FIN DETAIL
SCALE: 3/8"=1'-0"



REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WILTAM, VERM.

**CONNECTICUT RIVER FLOOD CONTROL
ST. JOHNSBURY LOCAL PROTECTION**

SECTIONS & DETAILS

PASSUMPSIC AND SLEEPERS RIVERS VERMONT

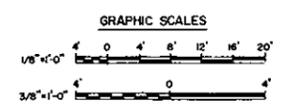
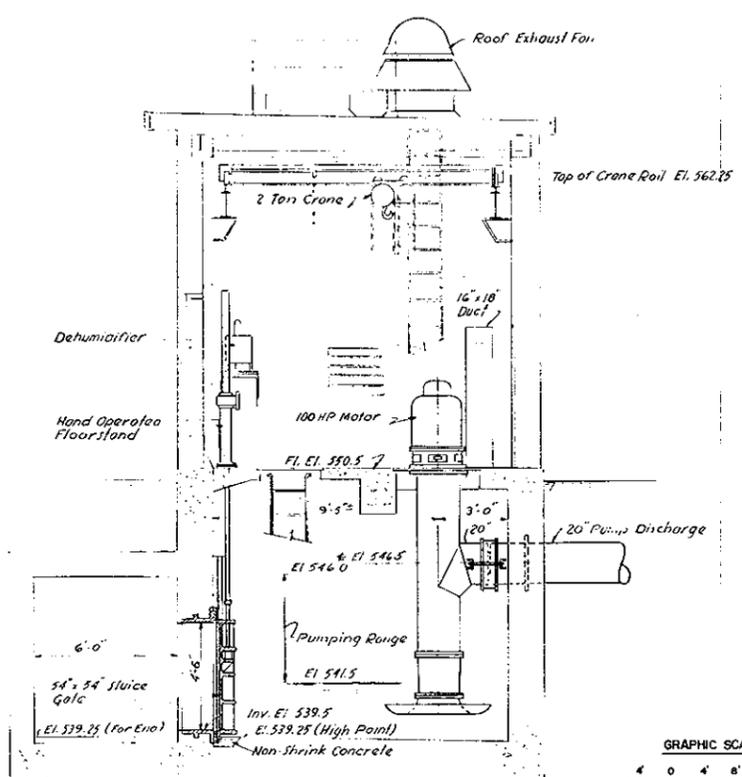
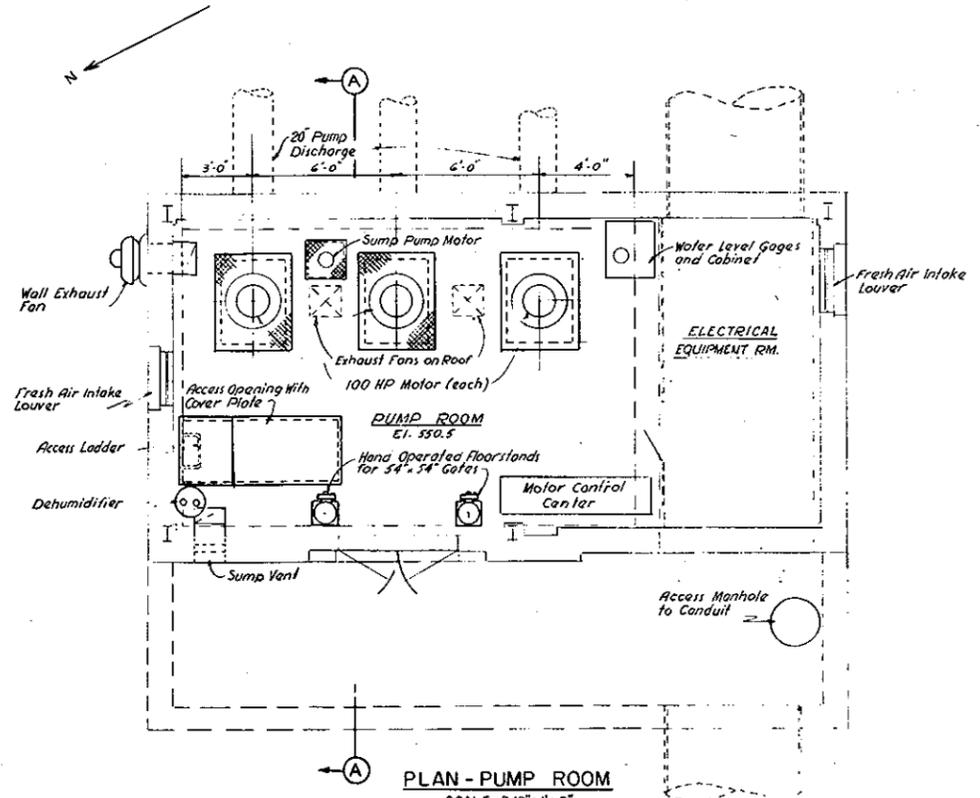
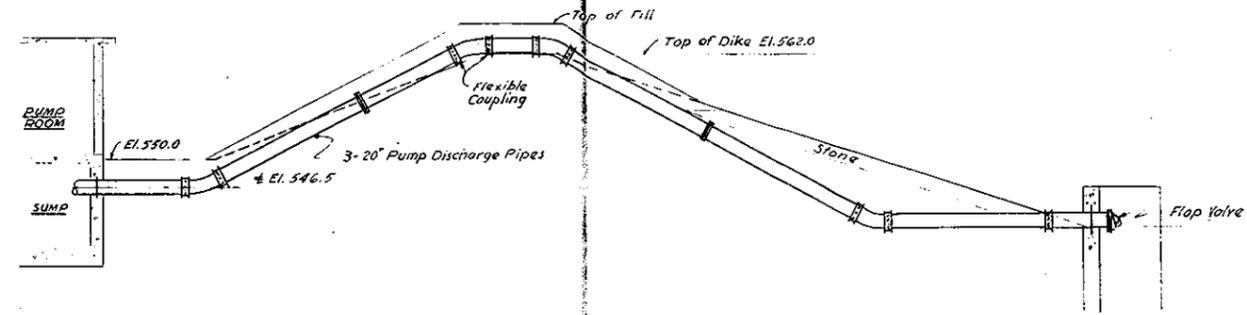
DATE: JAN. 1967

SCALE: 3/8"=1'-0"

SHEET

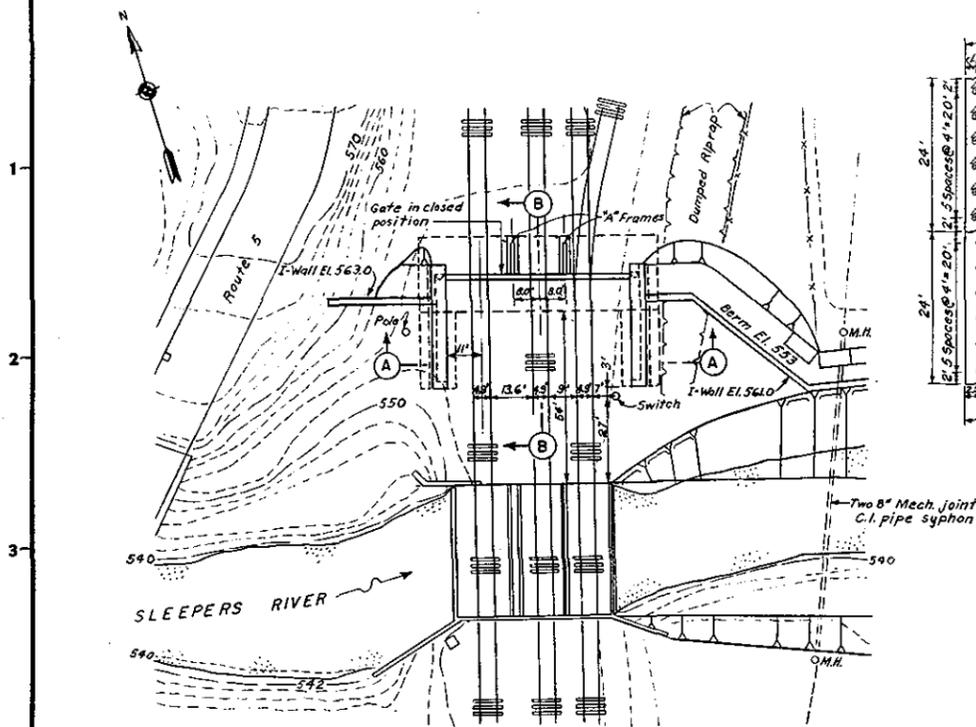
1
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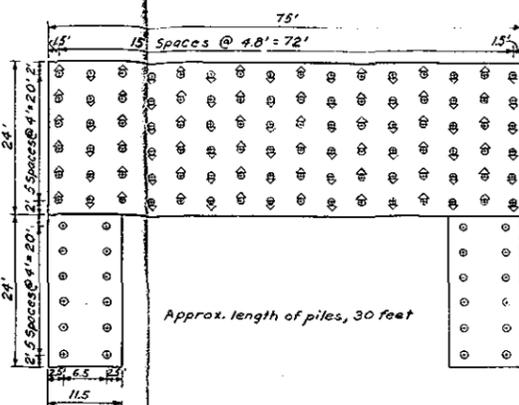


REVISION	DATE	DESCRIPTION	BY

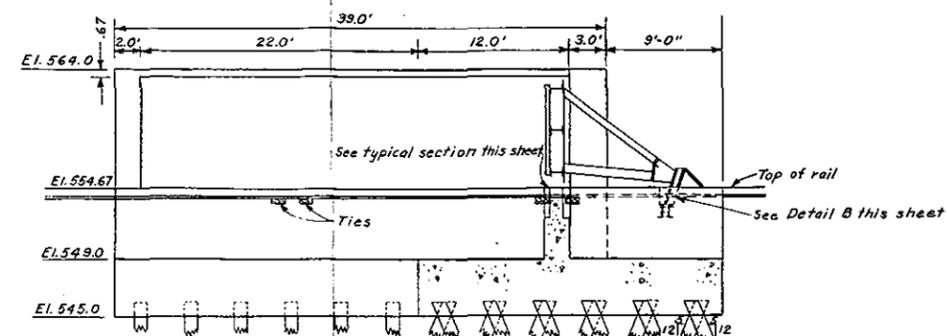
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.			
DES. BY	DR. BY	CL. BY	CONNECTICUT RIVER FLOOD CONTROL ST. JOHNSBURY LOCAL PROTECTION PUMPING STATION MECHANICAL
SUBMITTED:			
PROJECT ENGINEER			
APPROVAL RECOMMENDED			
PASSUMPSIC AND SLEEPERS RIVERS VERMONT			DATE JAN. 1967



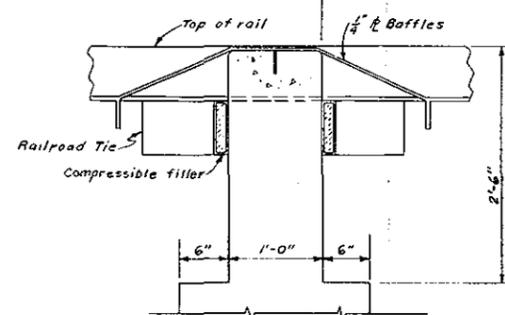
PLAN OF RAILROAD GATE
SCALE: 1"=20'



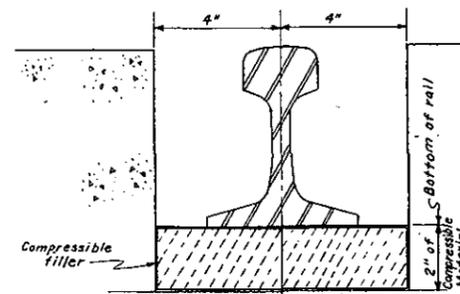
PILE PLAN
SCALE: 1"=10'



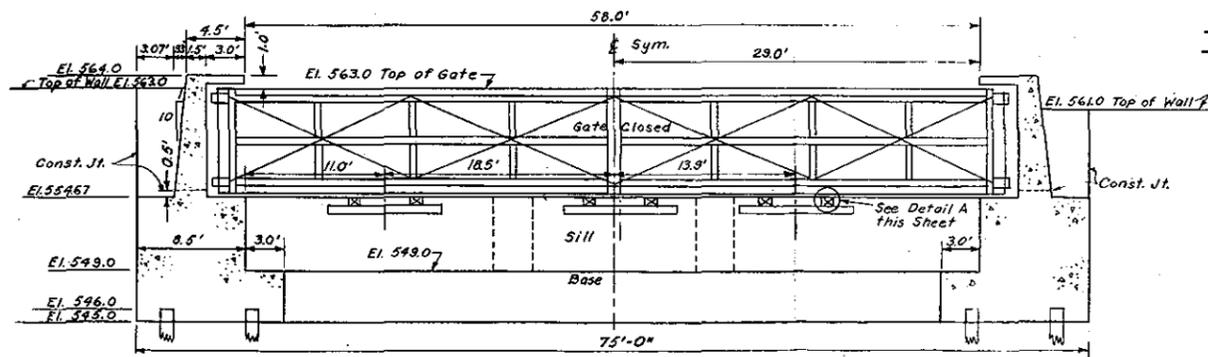
SECTION B-B
SCALE: 1"=5'-0"



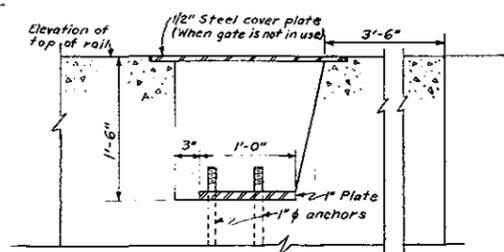
TYPICAL SILL SECTION AT TRACK
SCALE: 1/2"=1'-0"



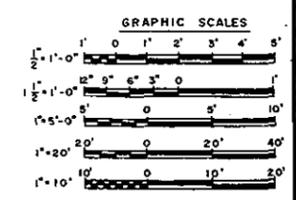
DETAIL A
SCALE: 1/2"=1'-0"



SECTION A-A
SCALE: 1"=5'-0"



DETAIL B
SCALE: 1/2"=1'-0"

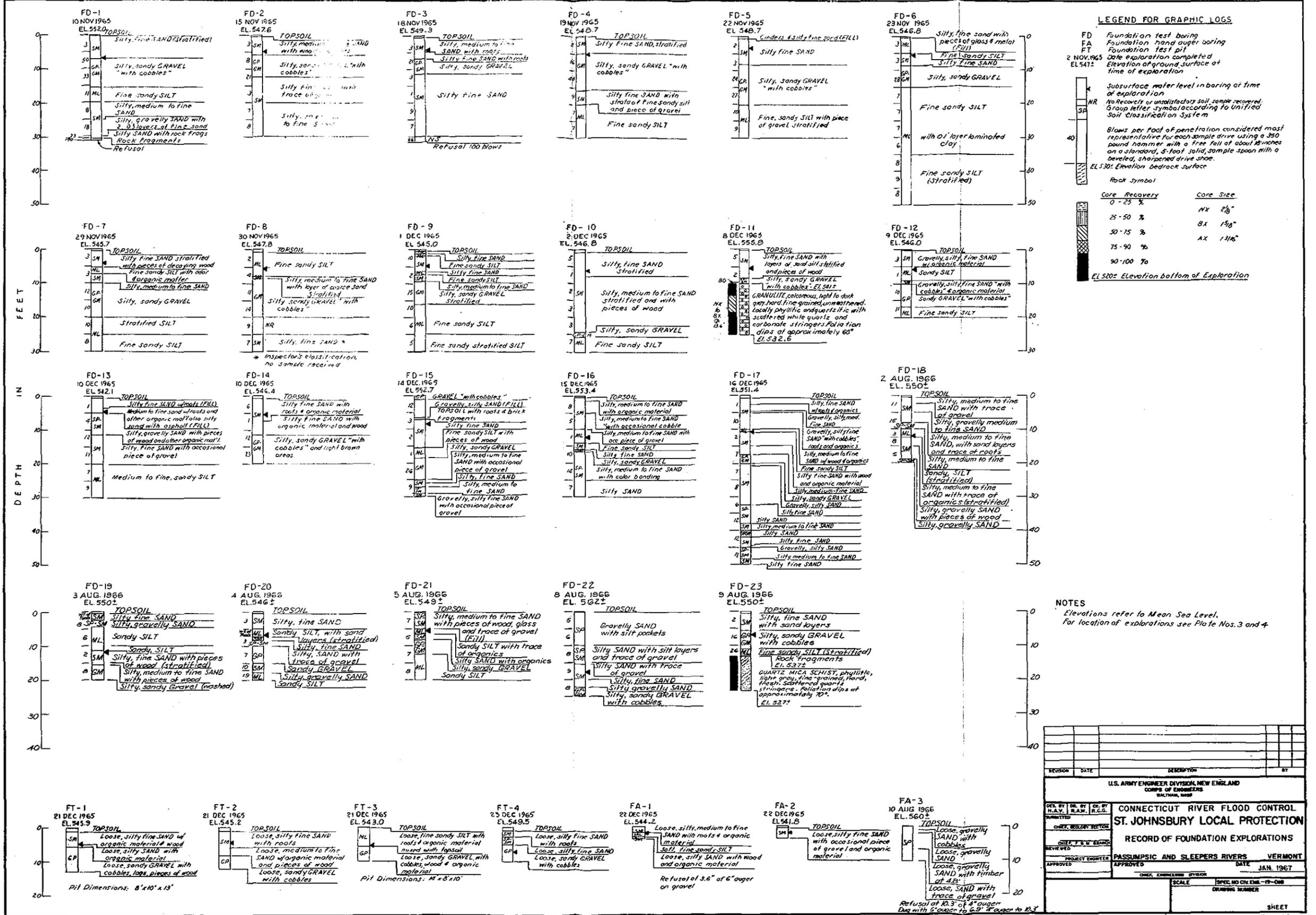


REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTON, MASS.

CONNECTION RIVER FLOOD CONTROL
ST. JOHNSBURY LOCAL PROTECTION
RAILROAD GATE
PLAN AND SECTIONS
PASSUMPSIC AND SLEEPERS RIVERS VERMONT
APPROVED: [Signature] DATE: JAN. 1967

SCALE AS SHOWN SPEC. NO. []
DRAWING NUMBER: []
SHEET: []



APPENDIX A

LETTERS OF CONCURRENCE AND COMMENT

APPENDIX A

LETTERS OF CONCURRENCE AND COMMENT

<u>Exhibit No.</u>	<u>Agency</u>	<u>Letter Dated</u>
1	Town of St. Johnsbury, Vermont	10 Nov. 1966
2	U. S. Department of Agriculture Soil Conservation Service	21 June 1965
3	U. S. Department of Health, Education, and Welfare, Regional Office	12 July 1965
4	U. S. Department of the Interior Fish and Wildlife Service	12 July 1965
5	State of Vermont Department of Water Resources	16 Mar. 1965
6	Canadian Pacific Atlantic Region	29 Nov. 1966

TOWN SELECTMEN

Richard N. Bohlen
Edward A. Gray
Herman R. Hoyt



John W. Simons, Jr.
Orlando P. Costa

Town of St. Johnsbury

OFFICE OF TOWN MANAGER

DAVID T. CLARK

ST. JOHNSBURY, VERMONT 05819

November 10, 1966

Colonel Remi O. Renier
Acting Division Engineer
U.S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Renier:

We have examined the plans prepared by your office for overbank and ice-jam flood protection along the Passumpsic and Sleepers Rivers in St. Johnsbury, as shown on Plates 1 to 10 and concur in general with this plan of protection.

In our opinion, if and when the project is authorized and funds are allotted for its construction, the Town of St. Johnsbury will meet the prescribed requirements of local cooperation and will agree to: provide without cost to the United States, all lands, easements and rights-of-way necessary for the construction of the project, presently estimated at \$36,000; provide without cost to the United States, all necessary modifications to existing utilities presently estimated to cost \$25,000; hold and save the United States free from damages due to the construction works; maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army, currently estimated at \$3,000 per year; and assume full responsibility for all project costs in excess of the Federal cost limitation of \$1 million.

As you are aware, the power to appropriate money comes from a vote of the people. However, there is little doubt that a project of this nature with its attendant benefits to all concerned would receive a favorable vote.

You may consider this letter as one of intent by the Town to cooperate locally on this project as is required by the authority of Section 205 of the 1948 Flood Control Act, as amended.

Yours Very truly,

David T. Clark
Town Manager for the Selectmen
of the Town of St. Johnsbury

EXHIBIT NO. 1

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

19 Church Street
Burlington, Vermont 05401
June 21, 1965

Mr. John Wm. Leslie, Chief
Engineering Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie:

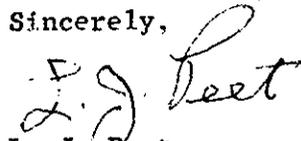
Your File NEDED-D

Thank you very much for your letter of June 16 concerning the local flood protection project along the Passumpsic and Sleepers Rivers, St. Johnsbury, Vermont.

It appears that this project will have no effect, nor will it be affected by, any project we contemplate at this time.

Thank you again for keeping us informed of your activities in Vermont.

Sincerely,



L. J. Peet
State Conservationist

EXHIBIT NO. 2

sewage flow to the pumping station for discharge to the river. The Vermont Department of Water Resources estimates that the average dry-weather flow is in the vicinity of 2 MGD with wet weather flows reaching 8 MGD. However, they feel these flows should be checked at the time of final design.

Thank you very much for the opportunity to comment on this project; and if we can be of further service, please do not hesitate to call.

Sincerely yours,



Earl J. Anderson
Acting Regional Program Director
Water Supply and Pollution Control
Public Health Service



PUBLIC HEALTH SERVICE

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE

Region I
120 Boylston Street
Boston, Massachusetts 02116

July 12, 1965

General R. R. Ploger
Division Engineer
U. S. Army Engineer Division
New England
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Attn: Mr. John Wm. Leslie
Chief, Engineering Division

Dear General Ploger:

In response to your letter of June 8, 1965, requesting comments on the local flood protection project along the Passumpsic and Sleepers Rivers in the Town of St. Johnsbury, Vermont, the following suggestions are respectfully submitted.

1. Consideration should be given to enclosing the storm water pumping station within the sewage treatment plant fenced area. This would improve the security of the building and allow the station to be maintained by the operator of the sewage treatment plant.
2. As part of the Sleepers River relocation, the sewage treatment plant outfall should be relocated to insure proper dilution of the effluent at low flow periods. The Vermont Department of Water Resources has reported to us that experience at the plant has shown that the discharge at the confluence of the Sleepers and Passumpsic Rivers is necessary to avoid adverse river pollution conditions.
3. Inasmuch as the project will offer protection from a maximum water surface elevation of 557 and within the sewage treatment plant, the elevation of the main floor of the control and Administration Building and the top of the concrete tanks is 550, a gate should be provided in the treatment plant outfall line to prevent flood waters from backing up and inundating the plant. Consideration should also be given to diverting the

EXHIBIT NO. 3



UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE

U. S. POST OFFICE AND COURTHOUSE
BOSTON, MASSACHUSETTS 02109

July 12, 1965

Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Sir:

Reference is made to Mr. Leslie's letter of June 8, 1965 advising this office that you are preparing a Detailed Project Report for flood control on the Passumpsic River at St. Johnsbury, Vermont. The map attached to your letter indicates that the tentative plan of improvement includes a dike approximately 3,200 feet long that would be located on the west bank of the river along the Loop Area. It is our understanding that this dike would extend a short distance upstream on the north bank of the Sleepers River enclosing the municipal sewage plant. A short reach of the Sleepers River would be relocated.

Based on our knowledge of the area, we believe that the planned local flood protection works within the limits of the project area as described above will not significantly affect the fish and wildlife resources; neither would there be any appreciable opportunity for improvement of these resources.

In view of the above we do not plan to report on this project.

Sincerely yours,

Thomas A. Schrader, Chief
Division of Technical Services



STATE OF VERMONT
DEPARTMENT OF WATER RESOURCES
MONTPELIER
05602

March 16, 1965

Colonel E. J. Ribbs
Acting Division Engineer
U. S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Mass.

Re: Reconnaissance Scope Study -
St. Johnsbury, Vermont

Dear Colonel Ribbs:

This office has been advised of the details of the referenced project through a copy of your February 19, 1965 letter to the Town of St. Johnsbury. This office has reviewed the material and has the following comments:

- (a) Consideration should be given to increasing the fenced area of the sewage treatment plant site and to locating the storm water pumping station within the compound. This will enhance the protection of the pumping station and allow for the sewage treatment plant operator to maintain the pumping station.
- (b) The sewage treatment plant outfall should be relocated as a part of the Sleepers River relocation to insure proper dilution of the effluent during low flow periods. Experience at the plant has indicated that discharge at the confluence of the Sleepers and Passumpsic Rivers is necessary to avoid adverse river pollution conditions.

It is the opinion of this office that these minor changes would improve the project and urge that you give them favorable consideration.

Sincerely,


Commissioner

RWT:ms
cc: Mr. David T. Clark
Town Manager
St. Johnsbury

EXHIBIT NO. 5

R. E. Farmer,
Regional Engineer
R. A. Swanson,
Asst. Regional Engineer

Canadian Pacific

ATLANTIC REGION — WINDSOR STATION, MONTREAL 3, QUE.

November 29, 1966
File No. T66/77

Department of the Army,
New England Division,
Corps of Engineers,
424 Trapelo Road,
Waltham, Mass., 02154.

Gentlemen:

Please refer to your letter of August 23 regarding proposed flood protection at St. Johnsbury, Vermont, and conversation of November 28 between your Mr. Legro and Mr. Grant of my office.

An estimate for the cost of the project is nearing completion and it is expected to have this forwarded to you with comments and suggestions in the near future.

Yours truly,


Regional Engineer.

APPENDIX B

FLOOD LOSSES AND BENEFITS

APPENDIX B

FLOOD LOSSES AND BENEFITS

<u>Paragraph</u>	<u>Subject</u>	<u>Page</u>
1	Damage Surveys	B-1
2	Loss Classification	B-1
3	Recurring Losses	B-1
4	Annual Losses	B-1
5	Trends of Development	B-2
6	Tangible Benefits	B-3
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B-1	Stage Damage Curve
B-2	Damage Frequency Curve

APPENDIX B

FLOOD LOSSES AND BENEFITS

1. DAMAGE SURVEYS

Damage surveys on a systematic basis were first made in the Loop area at St. Johnsbury following the floods of March, 1936. Review surveys were made in 1948 and 1950 and a complete re-survey was made in 1964. The 1964 survey was a detailed property-by-property review using interviews with operators of each of the facilities involved. Flood losses were determined for each property at the flood height of the 1927 event and at various stages of flooding above and below the record 1927 level. The stage where damage begins, referenced to the 1927 stage, was also determined for each property.

2. LOSS CLASSIFICATION

Losses in the Loop area would be incurred by two industrial plants, several commercial ventures, railroad trackage serving the area, town roads and the town's modern sewage treatment plant.

The losses recorded were classified as physical, i. e., damage to grounds, structures, machinery and contents of structures, and road-beds of tracks and roads, and non-physical-losses in wages, profits and continuing fixed costs during period of flood interruption of normal business. Emergency costs such as the almost yearly blasting of ice jams in the area to prevent flooding were also recorded.

3. RECURRING LOSSES

A recurrence of the record flood stages of November 1927 would cause losses in the Loop area estimated at \$545,000 under present day (1966) conditions.

4. ANNUAL LOSSES

Estimated recurring losses at various stages of flooding were combined with stage frequency data to derive annual losses. Annual losses in the Loop area amount to \$49,600 at 1966 price levels. Plates B-1 and B-2 show derivation of annual losses.

5. TRENDS OF DEVELOPMENT

St. Johnsbury is the largest community and the commercial center of northeastern Vermont.

The town is served by rail (freight) transportation with the Canadian Pacific's Sherbrooke, Quebec to Wells River, Vermont line passing through in a north-south direction, the St. Johnsbury and Lamoille Valley connecting the area with Lake Champlain to the west, the Maine Central giving service to northern New Hampshire and Maine to the east and the Boston and Maine by connection with the Canadian Pacific at Wells River giving service to the south and east.

Two nationally numbered highway routes cross in the town, Vermont - U. S. 2 in an east-west direction meeting Vermont - U. S. 5 running north and south between southern New England and Canada.

To the south of St. Johnsbury, Interstate Route I-91 is under construction in the White River Junction area (it is already completed between White River and the Vermont-Massachusetts line) and the road is expected to be completed to St. Johnsbury by 1970. This is expected to have a large impact on the economy of the entire region around St. Johnsbury.

In population, the town, like the surrounding counties, has shown a slight decline over the past two decades. A "Projective Economic Study of New England" prepared for this office in the period 1964-1965 by Arthur D. Little, Inc., Cambridge, Mass., in connection with the Comprehensive Survey of the Connecticut River forecasts a reversal of the decline by 1980 and an increase of over 85 percent in the population of the counties centered around St. Johnsbury by the year 2020.

The same study projects employment in manufacturing to increase by 119 percent in these counties by 2020 and employment in the service industries to increase by 152 percent. These data forecast at least a continuation of the present stable state of the economy of St. Johnsbury over the 50-year life of the recommended project. This will mean that the protected area, because of the desirability of its location will be kept in present use or similar use over the project life. Because of present intensity of use and the limited extent of the area, however, little support exists for a forecast of more intensive use of the site over the project life.

6. TANGIBLE BENEFITS

Tangible annual flood damage prevention benefits were derived as the difference in annual losses to be expected over the life of the project without protection and those to be expected after the project is constructed. Annual benefits, so derived, amount to \$40,000. In the determination of losses under pre-project conditions, it was assumed that the authorized Victory Dam and Reservoir, which is currently the subject of an Interim Report, would be in operation.

In addition to prevention of flood damages, the project will relieve the necessity of blasting ice jams in the project area to lessen the flood threat. Costs to the town of such blasting average \$7,000 on an annual basis.

Total tangible benefits to construction of the project amount to \$47,000.

7. INTANGIBLE BENEFITS

Important intangible benefits also will accrue to construction of the proposed project. With the current concern for pollution control, the most noteworthy of these will be the lessening of the danger of disruption of the operation of the St. Johnsbury sewage treatment plant. Disruption of normal business activities in an important segment of St. Johnsbury will also be avoided.

8. SECONDARY BENEFITS

St. Johnsbury and much of the surrounding area is currently classified as a Qualified Title I Area under P. L. 89-136, "The Public Works and Economic Development Act of 1965." Until 30 June 1966, Caledonia County, of which St. Johnsbury is the county seat, was a Title IV Area and eligible for the claiming of Redevelopment Benefits. Improving economic conditions in a portion of the county resulted in the lower classification. With a slight decline in employment or income, the area could be once more eligible for redevelopment benefits for public works projects. With an estimated construction cost of \$826,000, this secondary benefit would amount to \$4700 annually over the 50-year life of the project. This assumes normal practice of local hiring and making appropriate allowance for the number of locally hired personnel who would be unemployed or underemployed on this project.

STAGE IN FEET REFERRED TO 1927 FLOOD STAGE

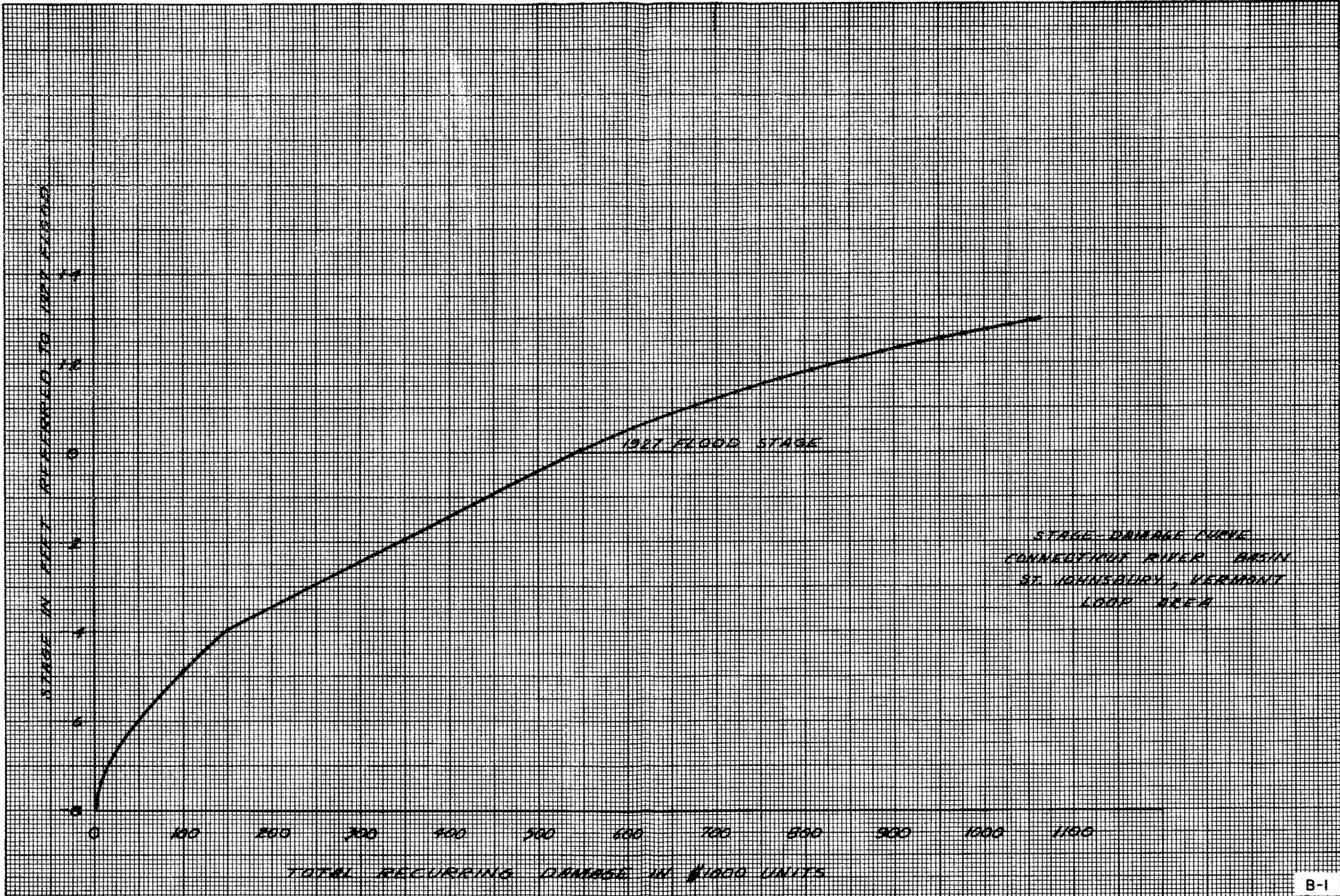
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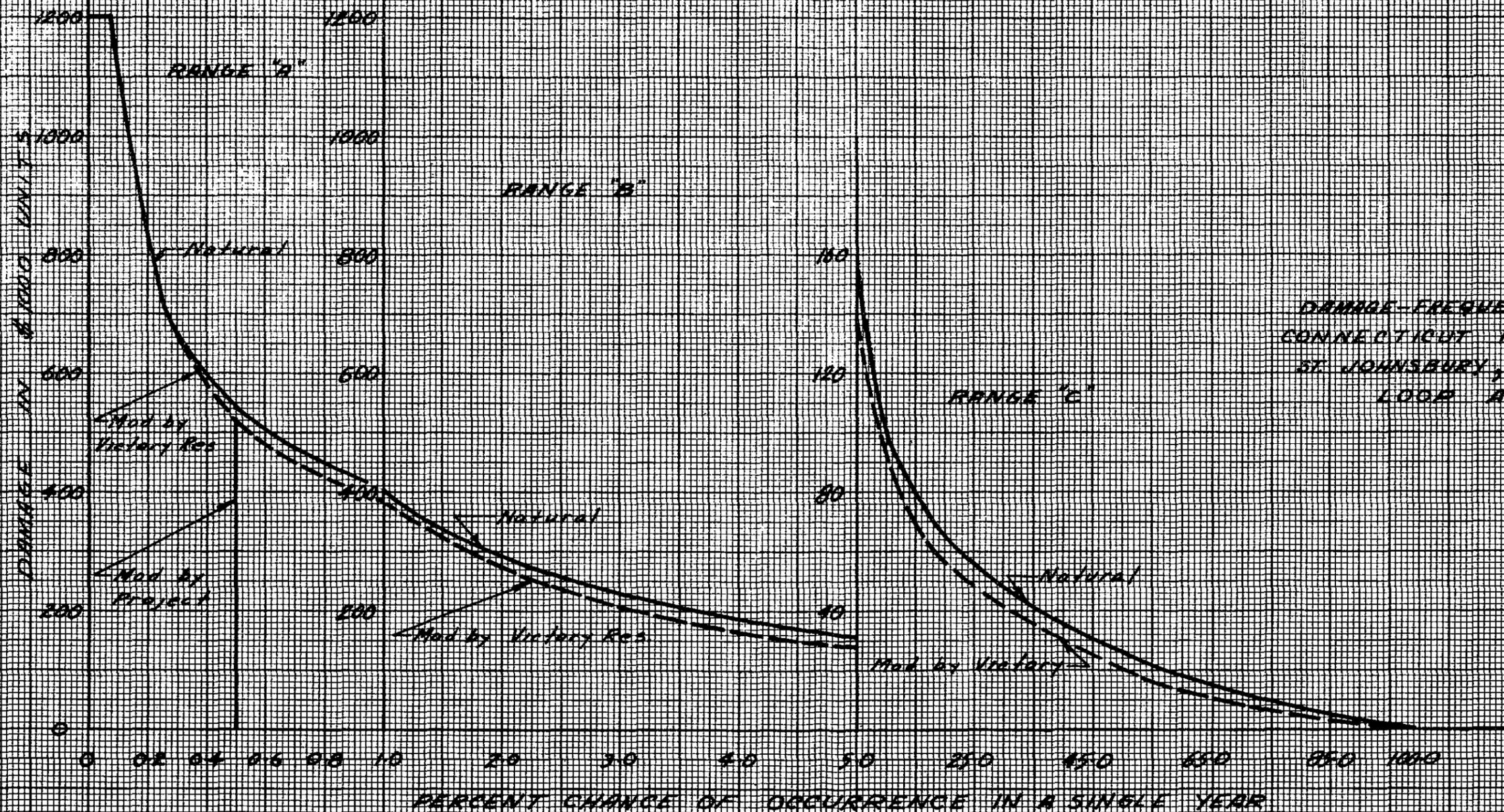
TOTAL RECURRING DAMAGE IN \$1000 UNITS

1927 FLOOD STAGE

STAGE DAMAGE CURVE
CONNECTICUT RIVER BASIN
ST. JOHNSBURY, VERMONT
LOOP AREA



	RANGE "A" 1" - \$2,000			RANGE "B" 1" - \$2,000			RANGE "C" 1" - \$2,000			TOTAL ANNUAL	
	AREA	LOSS	BEN.	AREA	LOSS	BEN.	AREA	LOSS	BEN.	LOSS	BENEFIT
Natural	2.00	6,400	—	4.90	9,800	—	4.10	32,800	—	\$49,000	—
Modified by Victory Res.	7.82	6,860	140	4.29	9,100	700	3.58	28,140	4,160	\$44,000	\$5,000
Mod. Prod. by Project	5.99	4,000	2,660	—	—	3,100	—	—	22,640	\$4,000	\$10,000



APPENDIX C

HYDRAULIC DESIGN

APPENDIX C
HYDRAULIC DESIGN

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2	Design Flood	C-1
3	Water Surface Profiles	C-1
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5	Interior Drainage	C-2
6	Design Criteria	C-2
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C-2	Discharge Frequency Curves
C-3	Passumpsic River Rating Curve
C-4	Development of Standard Project Flood

APPENDIX C

HYDRAULIC DESIGN

1. GENERAL

The proposed plan of improvement will consist of 2,300 feet of dike along the right bank of the Passumpsic River and 430 feet of dike and floodwall along the left bank of the Sleepers River. Included in the plan of protection are a pumping station, realignment of the Sleepers River from the railroad bridge to its mouth, a railroad gate structure at the railroad crossing and interior drainage facilities.

As previously noted in Paragraph 26 of the main report, Victory dam would afford limited non-ice flood protection and insignificant protection against ice jams. The local protection project will provide protection against major floods and lesser flows coincident with ice jams which are likely to occur during the late winter or early spring.

2. DESIGN FLOOD

The top grade of the dikes and floodwalls is predicated upon the project design flood profile and will provide for flood heights equivalent to the record flood plus 3 feet of freeboard. Although ice jams have occurred concurrently with moderately large discharges, it is highly improbable that ice conditions would occur coincident with a flood peak as large as the project design flood. The top grade of dikes and floodwalls will provide protection against more serious ice conditions than have been experienced to date.

The modified peak discharges of the project design flood in the Passumpsic River at St. Johnsbury, below the confluence of the Sleepers River and in the Sleepers River are 42,000 and 13,500 cfs, respectively.

3. WATER SURFACE PROFILES

The water surface profiles of the Passumpsic River, shown on plate C-1, were determined from field surveys of high water elevations resulting from the record flood of November 1927. A rating curve on the Passumpsic River upstream of the Sleepers River was developed from high watermarks and is shown on plate C-3.

It is estimated that average velocities in the Passumpsic River during the project design flood will range from 6 to 8 feet per second. Average velocities in the Sleepers River in the vicinity of the railroad bridge will vary from about 12 to 14 fps. Immediately below the bridge along the dike, velocities will decrease to about 10 to 12 fps. Losses through the railroad bridge, allowing for some accumulation of ice and debris were estimated at about 6 feet. A minimum freeboard of 3 feet was used throughout the project.

4. TRACTIVE FORCES AND RIPRAP REQUIREMENTS

Stone riprap protection will be provided on the riverside slope of the dikes and on the channel side slopes where the natural materials have been disturbed. The maximum unit tractive forces were computed and the minimum average riprap thicknesses (D50 minimum) were determined by methods described in the draft report: "Criteria for Graded Stone Riprap Channel Protection," dated 10 April 1966. The maximum unit tractive forces will vary from 8.2 lbs./square feet at the railroad bridge on the Sleepers River to 0.4 lbs./square feet at section 19+00 on the Passumpsic River. From chart 9 of the subject draft and assuming a specific weight of stone of 165 lbs./cubic feet, the D50 min's were found to vary from 0.1 foot along the Passumpsic River to 2.0 feet under the railroad bridge and 0.6 foot beyond the transition on the Sleepers River.

5. INTERIOR DRAINAGE

The interior drainage area within the system of dikes and floodwalls comprises 80 acres. This area was divided into three parts for hydrologic analysis as shown on plate C-1. Area 1, east of Railroad Street consists of 46 acres. A runoff coefficient of 0.6 was used for this section in the rational formula. Area 2, west of Railroad Street and east of South Main Street consists of approximately 34 acres. A coefficient of 0.4 was used in the rational formula for this area. Area 3, west of South Main Street will be diverted directly into the Sleepers River. This area drains approximately 14 acres. Part of the overland flow from an adjacent area consisting of approximately 36 acres and located west of Railroad Street and north of Eastern Avenue may also discharge into the protected area during periods of high runoff. This area has a storm sewer system which discharges into the river upstream of the protected area.

6. DESIGN CRITERIA

Precipitation data have been taken from the U.S. Weather Bureau Technical Paper No. 40, "Rainfall Atlas of the United States." Peak discharges computed for various rainfall frequencies are listed below:

<u>Rainfall Frequency (Years)</u>	<u>Peak Discharge Area 1</u>	<u>Peak Discharge Area 2</u>
1	37	18
2	43	21
5	58	19

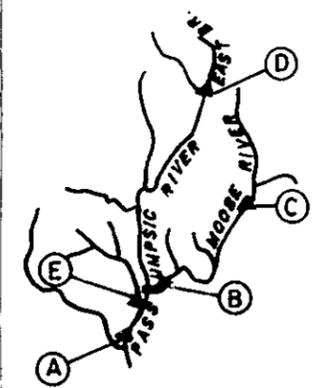
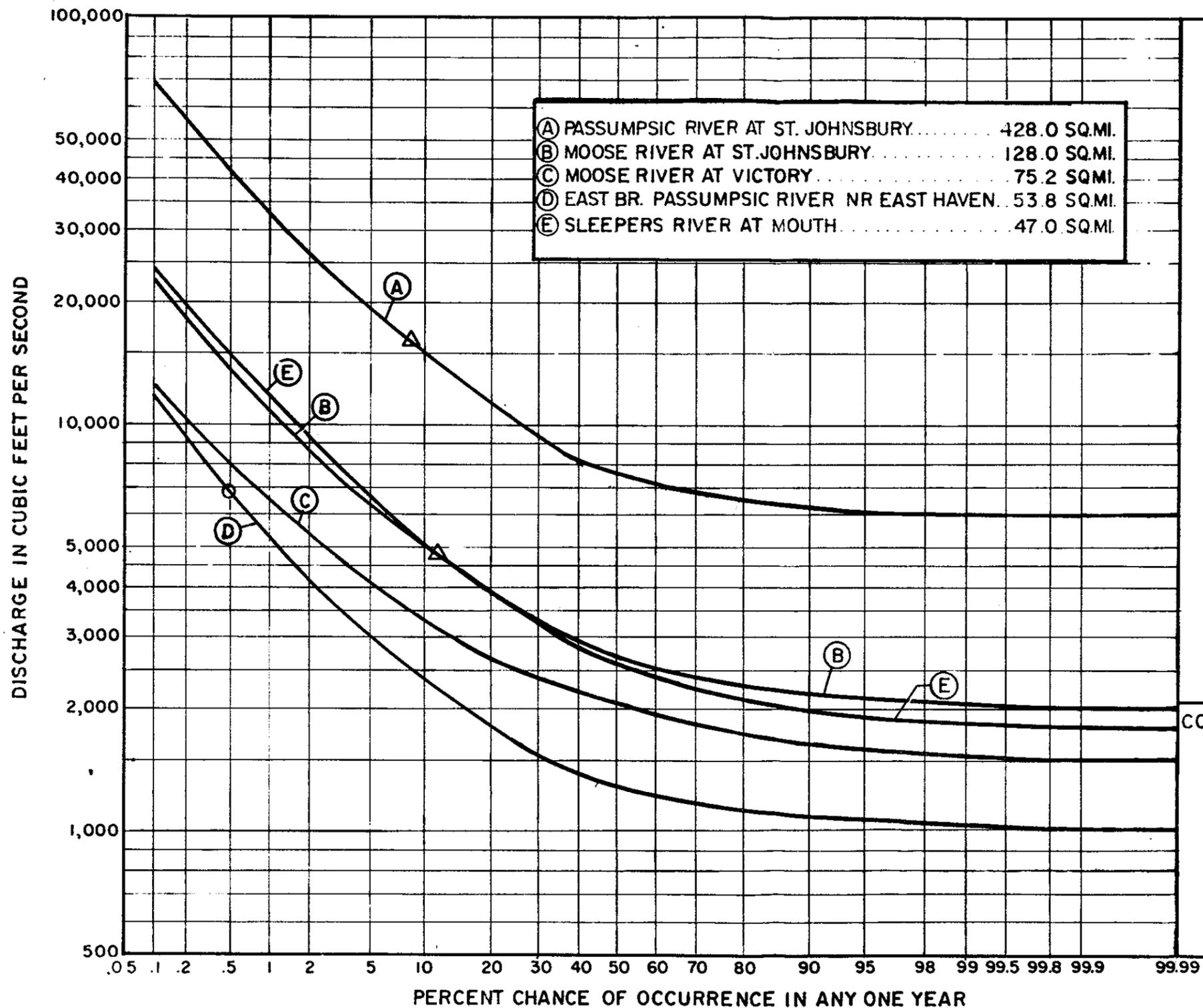
Surface runoff from Area 3 will be diverted by gravity into the Sleepers River. Using a coefficient of 0.4 in the rational formula, a 10-year frequency storm would result in a discharge from Area 3 of about 14 cfs. During the maximum river stage, the rate of seepage was estimated to be 2 cfs.

7. PUMPING STATION

One pumping station will be provided to discharge the interior runoff into the Passumpsic River during periods of high stage. There are no areas which may be developed for temporary storage of interior runoff within the protected area. Also some of the municipal storm drainage is combined with the sewerage system, which precludes the use of storage. The design of the pumping station, shown on plate C-1, was predicated on the 2-year storm coincident with high river levels. This criteria resulted in a design discharge capacity of 80 cfs, which includes runoff from Areas 1 and 2, seepage and minor contribution from the adjacent area north of Eastern Avenue.

A 30-inch conduit has been selected to divert interior runoff from the 14 acres contained in Area 3 to the Sleepers River. A conduit of this size is adequate to discharge a runoff of 14 cfs derived from the 10-year frequency storm.

A 66 inch diameter gravity outfall will be provided which will insure drainage from within the protected area to the Passumpsic River during periods of low flow. This conduit will be adequate to discharge 175 cfs at the normal river level which is equal to the runoff from the 100-year frequency storm.

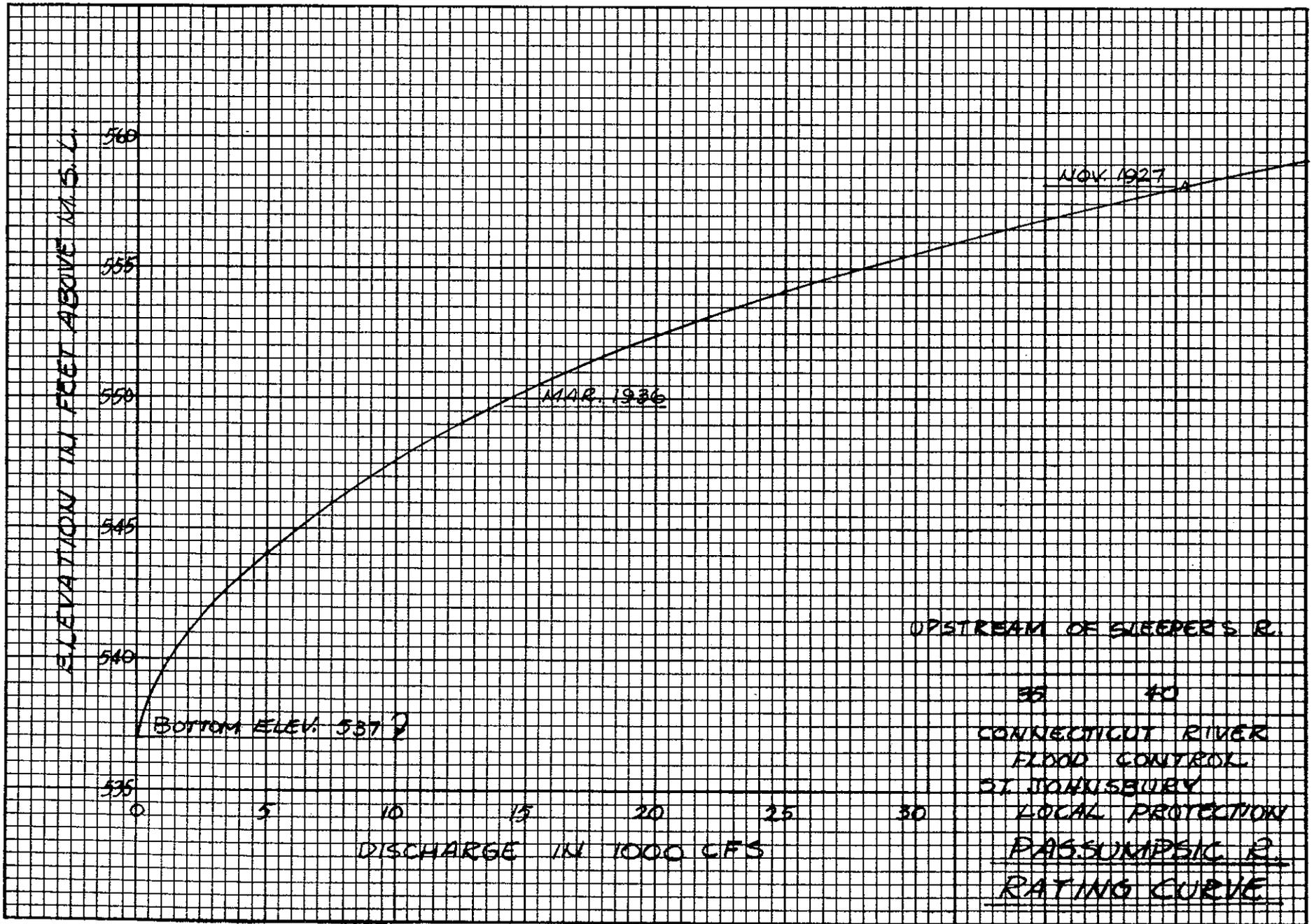


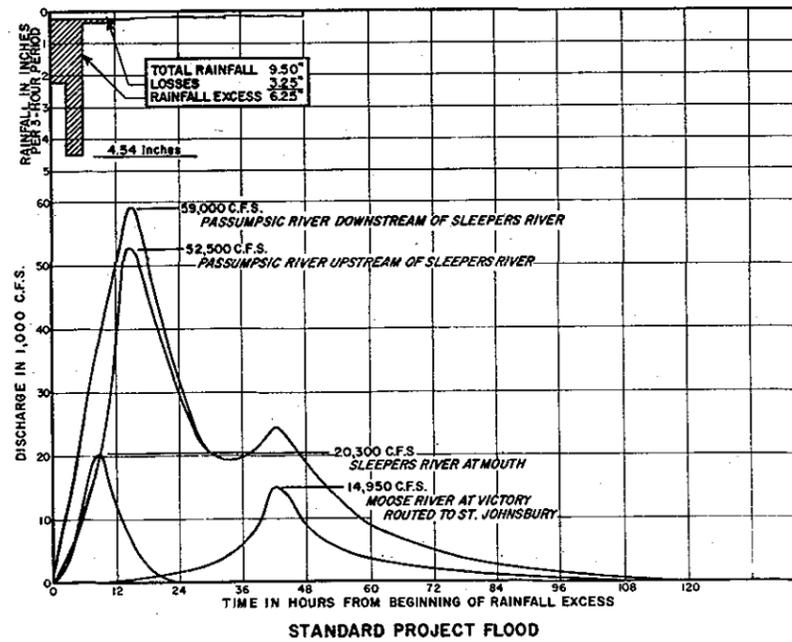
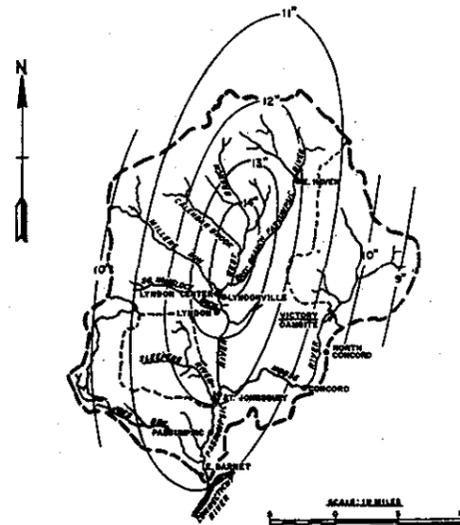
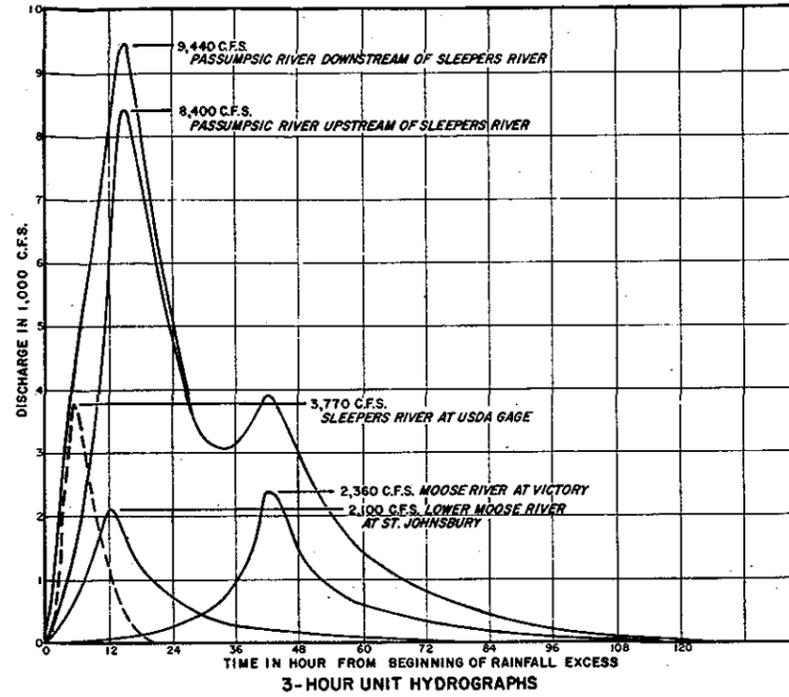
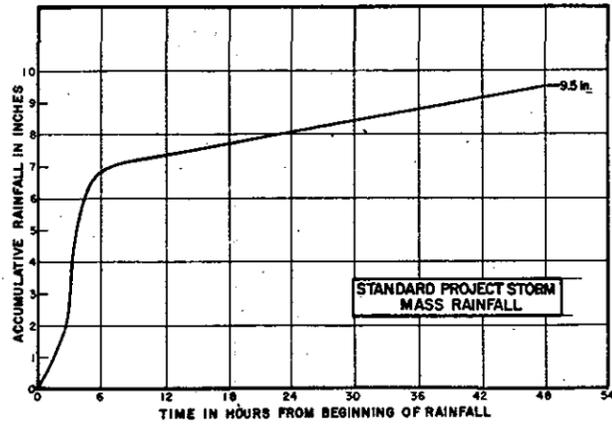
LEGEND:

- NOVEMBER 1927 FLOOD
- △ MARCH 1936 FLOOD
- X SEPTEMBER 1938 FLOOD

CONNECTICUT RIVER FLOOD CONTROL
 ST. JOHNSBURY LOCAL PROTECTION
**DISCHARGE-FREQUENCY
 CURVES**
 JANUARY 1967
 DEPARTMENT OF THE ARMY
 NEW ENGLAND DIVISION, CORPS OF ENGINEERS
 WALTHAM, MASS.

PLATE NO. C-3





DESIGNED BY	DATE	DESCRIPTION	BY
DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION, CORPS OF ENGINEERS DEPARTMENT OF THE ARMY			
PROJECT NUMBER	SECTION	CONNECTICUT RIVER FLOOD CONTROL ST. JOHNSBURY LOCAL PROTECTION DEVELOPMENT OF STANDARD PROJECT FLOOD	
APPROVED	DATE	PASSUMPSIC AND SLEEPERS RIVERS, VERMONT	
CHECKED	BRANCH	CHIEF, ENGINEERING DIVISION	
SCALE AS SHOWN		DRAWING NUMBER	
SHEET		SHEET	

APPENDIX D

FOUNDATION, EMBANKMENT AND CONCRETE MATERIALS

APPENDIX D

FOUNDATION, EMBANKMENT AND CONCRETE MATERIAL

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APPENDIX D

A. GEOLOGY

1. SURFICIAL AND SUBSURFACE INVESTIGATIONS

Geological investigations consisting of reconnaissance to evaluate foundation conditions generally and to assist in development of a program of required subsurface explorations was undertaken in July 1964. The results of these investigations were presented in Supplemental Reconnaissance Report, Passumpsic and Sleepers Rivers, Connecticut River Basin, Saint Johnsbury, Vermont, dated 26 February 1965. In 1965 additional reconnaissance was undertaken to investigate the availability of sources of borrow materials and a foundation exploration program consisting of twenty-three borings, four test pits and three auger borings was completed to provide information for preparation of final design.

All borings were continuously drive-sampled in overburden and bedrock encountered in borings FD-11 and FD-23 was diamond-drill cored to a penetration of 15 and 10 feet respectively. The test pits were excavated mainly to conduct field density tests on the foundation materials and to obtain large samples of the materials for laboratory tests. Some of the test pits and the auger borings were made to investigate the character of material in old channel fills which were suspected to contain trash and debris. The locations of all explorations are shown on General Plans, Plates 3 and 4. Descriptions and classification of materials encountered in all explorations are shown on Record of Foundation Explorations, Plate 10.

2. FOUNDATION CONDITIONS

Overburden in the site area consists of stratified sands, silts and gravels which extend generally to depths ranging from 30 feet to more than 50 feet except at the extreme north end of the dike where bedrock was encountered at depths of 11 to 13 feet along the foot of the terrace. At the surface generally throughout most of the site area, silty fine sand occurs to depths of 2 to 10 feet. A bed of sandy silt ranging in thickness from 2 to 8 feet occurs at a depth of 5 feet in the vicinity of boring FD-20 and extends southward interbedded with the silty sand to about Station 22+00. Southward from Station 22+00 the thickness of the silty sand increases

to more than 35 feet and in the vicinity of Sleepers River includes lenses of sandy silt and silty, sandy gravel which appear to be buried esker deposits. At scattered horizons to a depth of approximately 16 feet in the silty sand and sandy silt, fragments of wood and organic materials were encountered in many of the explorations. At the sewage treatment plant and along Sleepers River there are low dikes constructed of silty sand and gravelly, silty sand with some wood and trash. The dikes at the sewage treatment plant are ripped.

Underlying the upper deposits of sand and silt throughout almost the entire foundation area, there is an apparently continuous stratum of silty, sandy gravel ranging in thickness from 5 to 12 feet which lenses out southward in the vicinity of boring FD-10. At borings FD-12 and FD-14 south of Sleepers River, however, the gravel stratum again appears to be continuous.

The gravel is underlain throughout most of the area by sandy silt which is at least locally and probably generally more than 35 feet thick. Observation of water levels taken in borings and test pits during exploration indicate that subsurface water levels throughout the foundation area are essentially at or close to river level.

Bedrock encountered in borings FD 11 and FD 23 consist of calcareous granulite and quartz mica schist. The rock is relatively hard and fresh, locally phyllitic and quartzitic, and has numerous stringers of quartz and carbonate. Foliation, which is very well developed, dips 60° to 70°.

3. AVAILABILITY OF CONSTRUCTION MATERIALS

a. Random Fill. - Material for random fill sections of the embankment will be obtained from required excavations at the site. Beneath areas of artificial fill and nominal stripping, material from excavations will consist of silty sand and sandy silt with local zones of silty, gravelly sand to depths ranging from approximately 5 to 12 feet except in the vicinity of Sleepers River where these materials extend to depths of more than 20 feet. Silty, sandy gravel occurs generally beneath the sands and silt. It must be expected that water will be encountered in excavations deeper than 4 to 6 feet throughout the foundation area.

b. Impervious Material. - Borrow material required for construction of impervious sections of the embankment are available

from deposits of till within a radius of 5 miles of the site. Several of these deposits were sampled during reconnaissance in the area.

Area 1 is located 3-1/2 miles northwest of Saint Johnsbury and 1-1/2 miles southeast of North Danville. Haul distance to the site is approximately 4-1/2 miles. The material exposed in a highway cut is a highly modified till consisting of silty sand with scattered cobbles.

Area 2 is a till deposit believed to be of considerable extent located 1/4 mile north of the cemetery at Danville Center, 5 miles west of Saint Johnsbury at a haul distance of approximately 6 miles from the site. Material in this area, as exposed in a road cut, consists of gravelly, silty sand with cobbles and boulders.

In area 3 a deposit of till occurs on the north side of U. S. Highway Route 2 opposite the mouth of Stiles Brook, approximately 3 miles east of Saint Johnsbury. Haul distance to the site is 3-1/2 miles. The material exposed in a large highway cut consists of gravelly, silty sand with cobbles and boulders. However, nearby bedrock outcrops indicate the quantity of impervious material available in this area may be limited.

Area 4 is located 3 miles south of the site and approximately 1/2 mile east of the Passumpsic River. Exposures in road cuts and recent excavations show that the material in this area is gravelly, silty to clayey sand with cobbles and boulders. This deposit is very thick and extensive and provides a very large source of material for impervious fill.

c. Pervious Materials. - Material for pervious fill, gravel bedding and road gravel is available from several nearby sources. The town of Saint Johnsbury has recently been excavating gravels from the Passumpsic River immediately upstream from the site. Excavations have been carried to depths of 8 to 10 feet below river bed. The material was processed and put through a portable crusher to produce concrete aggregate. Adjacent to the site, the river channel shows practically continuous gravel and cobble bars which provide a large source of material which can be processed for select gravel requirements.

There is a large commercial pit in a high terrace located on Highway Route 5 directly opposite the access road to the Saint Johnsbury sewage treatment plant. The pit has a working face of approximately 40 feet with beds of fine to coarse gravel ranging from 6 to 10 feet in thickness interbedded with fine sand and silt.

Approximately 1 mile south of the above mentioned pit on Route 5, the town of Saint Johnsbury operates a pit in a similar terrace. The materials also are similar except that there is less gravel.

The town of Barnet has opened a large pit in a terrace on the east side of the river approximately 1-1/4 miles south of the village of Passumpsic. Haul distance to the site is approximately 5-1/2 miles. Material exposed in the 30-foot working face of the pit appears to be quite variable, ranging from coarse gravel and cobble beds to zones of fine gravel, fine to coarse sand and silty sand. Bedrock outcrops on the access road to the pit and it is reported that bedrock was encountered in the bottom of the pit in one area. In spite, however, of the apparent proximity of bedrock, there is a large quantity of material available in this deposit.

Processed sand and gravel are available from a commercial source in the area. The Caledonia Sand and Gravel Company operates a plant in the vicinity of West Waterford at a haul distance of approximately 9 miles from the site. Material for processing is obtained from a large esker at the plant site. The plant includes facilities for crushing, washing and screening to produce any required gradation.

d. Rock Slope Protection. - Bedrock in the Saint Johnsbury area consists generally of schists, phyllite, quartzite and calcareous granulite. All these rocks are highly foliated so that blasting would produce rock shapes which are thin, flat and elongated. Although some of these rocks are relatively hard, they tend to break down and weather rapidly. Over 20 years ago the town of Saint Johnsbury operated a quarry located on The Knob, a bedrock hill at the north end of town. Recent development of a residential area in the vicinity makes it very dubious if quarry operations there would be tolerated.

The Swasey quarry located on Highway Route 2, approximately 10 miles west of Saint Johnsbury, is excavated in quartz mica schist with included zones of calcareous granulite. As in the immediate vicinity of Saint Johnsbury, these rocks are thinly foliated and it is doubtful that satisfactory rock with suitable gradation and shapes could be obtained from this source.

The Caledonia Sand and Gravel Company is reported to be opening a quarry near their sand and gravel plant at Waterford where rock will be obtained for crushing to produce concrete aggregates. While it is possible that hard, durable rock with blocky type jointing may be available at this location, it is expected that the sizes produced may be too small for design requirements for use as slope protection. It is planned, however, that this quarry will be inspected when a significant quarry face is developed.

There are old abandoned quarries at Kirby Mountain located 9 miles northeast of Saint Johnsbury. Haul distance to the site is approximately 12 miles. Rock available is massive, blocky quartz monzonite, a granitic type rock, which could be blasted to produce suitably sized and graded rock for slope protection. The quarries, however, have not been operated for many years so that the old access road, approximately 1-1/4 miles long, is unusable because of wash-outs and would require extensive rebuilding to make a serviceable haul road.

A large potential source of rock for slope protection is available in the waste piles from the granite quarries at Barre. The granite is hard, sound and blocky but selection might be required to obtain satisfactorily graded sizes. Haul distance from the quarries to the site is approximately 45 miles.

e. Concrete Aggregates. In view of the small quantity of concrete required, investigations of aggregate material have been limited to consideration of commercial sources. Investigations made several years ago in connection with other flood control projects in the area, show that there are several commercial operations producing satisfactory concrete aggregates within 15 miles of the site. Complete data on re-evaluation of these sources and results of tests on any new sources which have been developed within the last few years is presented in Paragraph 7, Concrete Materials.

B. FOUNDATIONS AND EMBANKMENTS

4. CHARACTERISTICS OF FOUNDATION MATERIALS

a. Description and Distribution of Materials. -

(1) General. - Overburden in the foundation area of this project is generally over 50 feet thick except at the northern end of the Passumpsic River Dike where the bedrock surface rises to about 10 feet below the ground surface from Station 00/00 to Sta. 1/75. Subsurface water levels are generally at or slightly above the level of the adjacent river. Natural foundation soils occur in three relatively distinct zones: a thin surficial zone of very loose stratified uniform non-plastic silty fine sand and sandy silt, a middle zone of moderately compact silty sandy gravel and gravelly silty sand with cobbles, and a lower zone of moderately compact, stratified, uniform, non-plastic, silty fine sand and sandy silt. An Engineering log profile indicating the distribution of the foundation materials is shown on Plate No. D-1. Selected test data is shown on Plate No. D-2 and summaries of test results are shown on Plate Nos. D-6 through D-11.

(2) Passumpsic River Reach (Sta. 0/00 to 22/60). - In the foundation area along the Passumpsic River, the surficial zone of natural foundation soil is from 5 to 10 feet thick. The zone contains principally very loose silty fine sand except for lenses and pockets of sandy silt in the southern half of this reach. Silt contents of these soils range from 15 to 55 percent. There are occasional wood fragments scattered throughout this zone. The middle zone of natural foundation soil is from 5 to 12 feet thick. Gravel contents of the moderately compact, silty sandy gravel and gravelly silty sand in this zone are generally over 40 percent while silt contents range from 10 to 25 percent of the component passing the No. 4 Sieve. The lower zone of natural foundation soils is from 15 to 35 feet thick and contains both moderately compact silty fine sand and sandy silt with silt contents ranging from 15 to 85 percent. In the portion of this reach between Stations 6/50 and 15/00, the foundation area has been filled with up to 15 feet of moderately compact, silty fine and medium to fine sand.

(3) Sleepers River Reach (Sta. 22/60 to 26/95). - In the foundation area along the Sleepers River, the three zones of

foundation soils are less distinct and in some instances intermingled. The surficial zone of natural foundation soil is from 4 to 18 feet thick and contains very loose silty fine sand and sandy silt, with minor amounts of organic material and wood fragments. Silt contents of the soils in this zone range from 30 to 70 percent. The middle zone of natural foundation soil varies erratically from 3 to 12 feet in thickness. Soils in this zone consist of loose to moderately compact silty sand, gravelly silty sand, and silty sandy gravel having silt contents between 5 and 30 percent of the component passing the No. 4 Sieve. The lower zone of natural foundation soil is over 30 feet thick and contains moderately compact silty fine sand and sandy silt with occasional fine sand. In general, silt contents of the soils in this zone are between 30 and 70 percent. West of Station 26+00, however, there are strata of fine sand containing little or no silt. Over much of this reach, the area north of the Sleepers River has been filled with up to 10 feet of moderately compact silty fine sand for the construction of the sewage treatment plant and the railroad.

b. Shear Strength and Permeability. - No samples of the foundation soils were tested for shear strength or permeability. The following shear strength parameters for all conditions considered and average coefficients of permeability have been estimated for design purposes on the basis of experience with similar materials, inspection of the samples and their grain size distribution curves, and of field density data.

<u>Material</u>	<u>Shear Strength</u>		<u>Permeability</u>
	<u>ϕ, degrees</u>	<u>c, tsf</u>	<u>K X10⁻⁴ cm/sec</u>
Surficial Zone			
(Very loose silty fine sand and sandy silt)			
Compacted	25	0	15 to 120
Uncompacted	20	0	15 to 150
Middle Zone			
(Moderately compact silty sandy gravel and gravelly silty sand)			
	30	0	90 to 600
Lower Zone			
(Moderately compact silty fine sand and sandy silt)			
	25	0	3 to 30

It is estimated that the ratio of horizontal to vertical permeability is about 9 for all foundation materials.

c. Natural Densities. - Field density tests were performed in the surficial zone of natural foundation materials. The results of these tests and of maximum-minimum density tests performed on samples of these materials indicate that the relative density of this zone ranges from 20 to 50 percent. Non-plastic, saturated, uniformly graded, silty fine sand and sandy silt, of the types occurring in this foundation zone, are generally regarded as being susceptible to liquefaction at relative densities of less than 40 to 50 percent, although liquefaction in zones of such materials less than 20 feet thick is considered unlikely. For purposes of design, it is considered that this very loose foundation zone will require special treatment to eliminate any risk of liquefaction and to increase its shear strength. Over most of the dike foundation areas, partial removal of this zone and compaction of the remaining portion is practicable. Elsewhere removal of the material from critical portions of the foundation areas will be required.

d. Consolidation. - Consolidation tests were not performed on samples of foundation materials. Except for the soils in the surficial foundation zone, the foundation materials are of types exhibiting low compressibility. It is anticipated that settlements due to the consolidation of the very loose soils in the surficial zone after compaction will be small and will occur principally during construction.

5. DESIGN OF DIKES

a. Criteria. - Current design criteria as set forth in the pertinent sections of the Engineering Manual for Civil Works Construction, No. 1110-2-2300, "Earth Embankments" and regulations and bulletins referred to herein have been followed in the design of the dikes for this project.

b. Selection of Dike Sections. - Typical dike sections for this project are shown on Plate Nos. 5 and 6 of the main report. These sections have been developed from investigations and studies of foundation conditions and of the characteristics of available construction materials. The selected sections are essentially of the zoned rolled earthfill type with foundation drains, landside drainage zones, and small landside rock toes. The dikes are from 16 to 17 feet in height except in the reach between Stations 22/45 and

25/05 where the riverside slope reaches a maximum height of 24 feet. Landside slopes of 1 vertical on 2.5 horizontal and riverside slopes of 1 vertical on 3 horizontal have been adopted except in the reach from Station 24/34 to 26/85 where the riverside slopes will change from 1 vertical on 3 horizontal to 1 vertical on 2 horizontal because of space limitations imposed by the alignment of the proposed Sleepers River Channel and the sludge drying beds of the sewage treatment plant. Where the slope is steepened to 1 on 2, special foundation treatment involving additional excavation will be required. The sections have been designed to permit the utilization of material from the required excavations in the dikes with a minimum of selective excavation and waste.

c. Foundation Preparation. - As discussed in subparagraph 4c partial removal of the surficial foundation zone of very loose silty fine sand and sandy silt together with compaction of the remaining material with a vibratory roller will be done to provide a stable foundation for the dikes. In general, the foundation areas will be excavated to levels slightly above the subsurface water level prior to compaction. Where compaction of the foundation is not practicable this zone will be removed to its full depth in critical portions of the dike foundation areas. It is considered that this foundation treatment will provide an internally stable dike foundation having a shear strength adequate for the selected dike sections.

d. Characteristics of Dike Fill Materials. -

(1) General. - The quantity of suitable fill material available from the required excavations will not be sufficient to complete the dikes. Reconnaissance was made to locate potential off-site sources of earth fill and rock materials for dike construction. Several sources of glacial till were found within five miles of the project site. Several possible sources of embankment drainage materials and gravel bedding were found within 5 miles of the site as well as a large commercially developed source in the town of West Waterford, about 9 miles from the site. In view of the relatively small quantities of material required and the relatively high cost of developing government furnished borrow areas, it has been decided to have the contractor furnish all dike fill materials beyond those available from the required excavations.

(2) Impervious Fill. - Impervious fill material will consist of approved reasonably well-graded gravelly silty sand (glacial till)

furnished by the contractor. The material shall contain at least 25 percent fines, based on the component passing the No. 4 Sieve, and shall contain no more than 40 percent retained on the No. 4 Sieve. It is estimated that impervious fill material when compacted will have an average coefficient of permeability of less than 3×10^{-4} cm/sec. and will develop shear strength parameters in excess of $\phi = 30^\circ$ and $C = 0.1$ TSF within the anticipated applied stress range for all conditions considered.

(3) Random Fill. Random fill material will consist of approved material from the required excavations. The material will be principally silty fine sand, silty medium to fine sand, and sandy silt with minor amounts of sandy gravel and gravelly sand. Silt contents of the random fill materials will range from 15 to 50 percent, in general. It is estimated that random fill when compacted will have average coefficients of permeability between 15 and 120×10^{-4} cm/sec. and will develop an angle of internal friction of at least 30 degrees within the anticipated stress range for all conditions considered.

(4) Pervious Fill. Pervious fill material will consist of approved reasonably well-graded bank-run gravelly sand or sandy gravel furnished by the contractor. No more than 75 percent, by dry weight, of the material shall pass the No. 4 Sieve and no more than 15 percent of the component passing the No. 4 Sieve, by dry weight, shall pass the No. 200 Sieve. It is estimated that pervious fill material when placed will have average coefficients of permeability between 60×10^{-4} and 300×10^{-4} cm/sec. and will develop an angle of internal friction of at least 30 degrees for all conditions considered.

(5) Processed Sand Fill. Processed sand fill material will be furnished by the contractor and will consist of materials meeting the gradation specifications for fine concrete aggregates. It is estimated that processed sand fill will have an average coefficient of permeability in excess of 300×10^{-4} cm/sec. and will develop an angle of internal friction in excess of 30 degrees for all conditions considered.

(6) Processed Gravel. Processed gravel material will consist of approved processed gravel furnished by the contractor. The material shall meet the gradation requirements for coarse

concrete aggregate (3/4-inch to No. 4). It is estimated that processed gravel in place will have an average coefficient of permeability of at least 3000×10^{-4} cm/sec.

(7) Gravel Bedding. Gravel bedding material will consist of approved reasonably well-graded bank-run sandy gravel or gravelly sand furnished by the contractor. Of the portion of the material passing the 3-inch Sieve, between 25 and 60 percent, by dry weight, shall pass the No. 4 Sieve and no more than 15 percent, by dry weight, of the component passing the No. 4 Sieve shall pass the No. 200 Sieve.

(8) Rock Materials. Necessary rock materials will be furnished by the contractor. Although the possibility exists that necessary rock materials may be available from undeveloped or newly developed sources in the area, it was assumed for the purpose of this report, that rock materials would be furnished from waste piles of the granite quarries in Barre, Vermont, a haul distance of 45 miles.

e. Control of Seepage. In general, seepage through the dikes will be controlled by the arrangement and permeability differentials of the impervious, random and pervious fill zones, the processed sand and gravel zones, and the landside stone protection zone. Seepage through the dike foundation will be controlled by the natural riverside blanket, formed by the surficial zone of silty fine and sandy silt and the processed sand fill and processed gravel in the dike foundation drains which will be extended into the more pervious middle foundation zone of silty sandy gravel and gravelly silty sand. In the vicinity of the junction of the dike and the I-wall along the Sleepers River, seepage through the dike and its foundation will be controlled by an extension of the sheet pile I-wall into the dike and by a landside berm of processed gravel. Where existing or new utilities cross the dike foundation special seepage control measures including concrete encasement, and installation of seep rings and joint collars will be required. At junctions of concrete walls with the dike special construction methods will be required to insure a tight contact with the walls and a high degree of density in fill zones where compaction equipment cannot or should not operate effectively.

f. Slope Stability. The riverside slopes at Stations 18+00, 24+00 and 24+94 and the landside slope at station 18+00 were chosen

for analysis because maximum slope heights and depth of fine grained overburden materials occur at these locations. The analyses were performed assuming conditions analogous to those at the end of construction using the method of infinitesimal slices. The results of these analyses are summarized on plate No. D-3 and a typical analysis is shown on Plate No. D-4. The riverside slope at station 24+00 was also analyzed using the wedge method and the results are shown on plate No. D-5. The minimum factors of safety obtained by these analyses are tabulated below. Based on the results of these analyses it is considered that the selected embankment sections are safe against shear failure.

<u>Station</u>	<u>Min. F. S.</u>
18+00 (Riverside)	1.72
18+00 (Landside)	1.94
24+00 (Riverside)	1.48
24+00 (Riverside-wedge)	1.87
24+94 (Riverside)	1.51

g. Settlements. It is anticipated that, in general, settlement of the embankment foundation and embankment materials will not be significant and will occur during construction.

h. Slope Protection. The design of slope protection has been based on the criteria contained in draft Engineering Manual, "Criteria for Graded Stone Riprap Channel Protection," dated 20 April 1966, as modified by recent conferences between OCE and NED personnel.

Based on hydraulic computations, slope protection along the Passumpsic River would require stone with D50 sizes of .03 feet and therefore slope protection to resist erosive forces would be adequately afforded by topsoil. The nature of the river, however, indicates that during spring months the riverside slopes may be subject to major damage by the effects of ice. Experience has indicated that flood levels during ice break-up periods have reached an elevation of 550. It is therefore considered advisable to prevent major damage by ice by placing slope protection on the dike slope below elevation 553. Based on judgement, slope protection consisting of 24 inches of quarry run stone graded between 2 inches and a maximum of 24 inches is provided. Topsoil is provided above elevation 553.

Along the Sleepers River, erosive water forces require rock slope protection with a D50 (min) size of 0.6 feet along the reach from Sta. 22/60 to Sta. 24/94 and a D50 (min) size of 2.0 feet in the reach from Sta. 24/94 to Sta. 26/90. On the north side of the channel, stone protection layers of 15 and 42 inches for the downstream and upstream reach, respectively, have been selected. No slope protection has been provided on the south side of the channel since erosion of these slopes will not damage developed property. From Sta. 24/94 to Sta. 26/90, the 42 inch thick stone protection will extend across the channel bottom to prevent erosion at the toe of the north slope. In the reach where 15 inch thick stone protection will be provided, on the slope above the channel bottom, the slope protection will extend to a depth of 5 feet below the channel bottom. Below the channel bottom the slope protection will have a thickness of 21 inches. The selected stone to resist erosive forces will have the following gradations:

	<u>15 and 21 Inch Layers</u>	<u>42 Inch Layers</u>
W (Max)	170 lbs.	2300 lbs.
W50 (Min)	20 lbs.	700 lbs.
W50 (Max)	50 lbs.	1100 lbs.
W15 (Min)	4 lbs.	200 lbs.

6. FOUNDATIONS FOR CONCRETE STRUCTURES

a. Pumping Station. The pumping station will be constructed at the landside toe of the dike at approximately Station 20/60. The foundation for this structure will be founded below the zone of loose surficial fine grained material. The foundation materials at and below the elevations for all footings will consist of moderately compact, silty sandy gravel which extends for a distance of approximately 8 feet below the footing grade. This zone of gravel is underlain by a moderately compact deposit of sandy silts and silty fine sands in excess of 30 feet in thickness. The foundation soils are considered adequate for the foundation of the structure. No provisions are considered necessary for seepage control.

b. Railroad Gate. The railroad gate will be constructed at approximately Station 27/30. Overburden materials at the location of the structure consist of 16 to 19 feet of very loose, medium to fine

and fine sands, fine sandy silts, silty fine sands and silty medium to fine sands. The upper six feet, at least, of these materials have indications of being a fill placed for the existing railroad. Below these fine grained materials, loose to moderately compact, silty sands, gravelly silty sands, and sandy gravels exist to a depth in excess of 30 feet. The railroad gate structure will be constructed on a pile foundation which will carry loads through the upper zone of loose material. Foundation seepage will be controlled by a steel sheet piling cutoff.

C. CONCRETE MATERIALS

7. CONCRETE AGGREGATES

Approximately 1000 cubic yards of concrete will be required for the construction of concrete wall, pumping station and railroad gate structure. In view of the small quantity of concrete required, aggregate investigation has been confined to established commercial sources. A field reconnaissance was conducted by an engineer-geologist team to determine possible sources of supply. Two (2) commercial sources of sand and gravel and three (3) sources of ready mixed concrete are available.

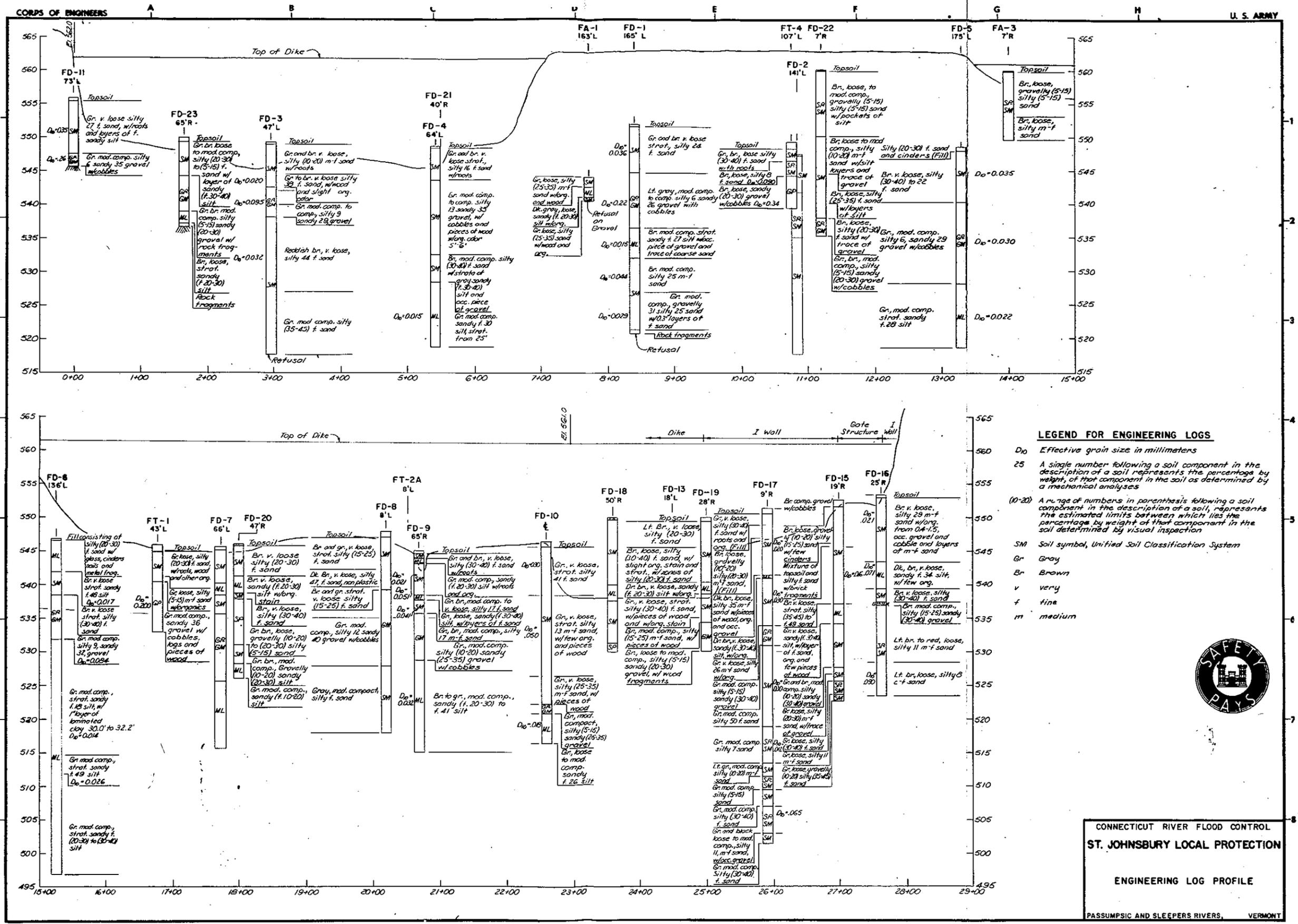
Caledonia Sand and Gravel Company. - The processing plant for sand and gravel is located in Waterford, Vermont, approximately a 10-mile haul distance to the project site. Data on this source are reported in Volume 5 of the Technical Memorandum No. 6-370, "Concrete Aggregates in the Continental United States Latitude 44° N and Longitude 71° W, Index No. 1." A field petrographic examination indicates the material is similar to that which has previously been tested. Quoted plant prices are \$2.00 per ton for gravel and \$1.00 per ton for concrete sand, and delivered prices of \$2.45 per ton for gravel and \$1.45 per ton for sand. Caledonia Sand and Gravel Company operates a manual control transit mixed type concrete plant on Route 18 in Waterford, Vermont, approximately an 86 mile haul distance from the project site.

Lawrence Sangrav Company. - The processing plant for sand and gravel is located in Guildhall, Vermont in a terrace deposit approximately a 34-mile haul distance to the project site. A field petrographic examination indicates the material petrographically is composed of approximately 50% granitic rock types, 25% dark basic rock types, 15% quartz and quartzite and 10% schist and shale. Lawrence Sangrav Company utilize these aggregates in ready mixed concrete supplied from manual control transit mixed type concrete plants, one located at the aggregate processing plant, and the other on Route 2, St. Johnsbury, Vermont. Quoted plant prices are \$2.00 per ton for gravel and \$.70 per ton for concrete sand, and delivered prices of \$3.65 per ton for gravel and \$2.25 per ton for sand. Because of the long haul distance to the St. Johnsbury concrete plant, this company indicated they are investigating possible sources of

material nearer to this plant. Since the source of aggregate for the St. Johnsbury concrete plant cannot be firmly established, investigational testing will not be performed at this time.

Calkins Redimix Concrete. - This company operates a manual control transit mix type concrete plant in Lydonville, Vermont, approximately an 8-mile haul distance to the project site. Fine and coarse aggregates utilized in their concrete are obtained from Caledonia Sand and Gravel Company, Waterford, Vermont.

It is recommended that although aggregates from both Caledonia and Lawrence Sangrav Companies would probably be acceptable for use on the project, that neither source of aggregate be listed as approved. If submitted for construction, material from Caledonia will be accepted on the basis of checktesting, and material from the Lawrence Sangrav Company will be accepted only after evaluation testing is performed.

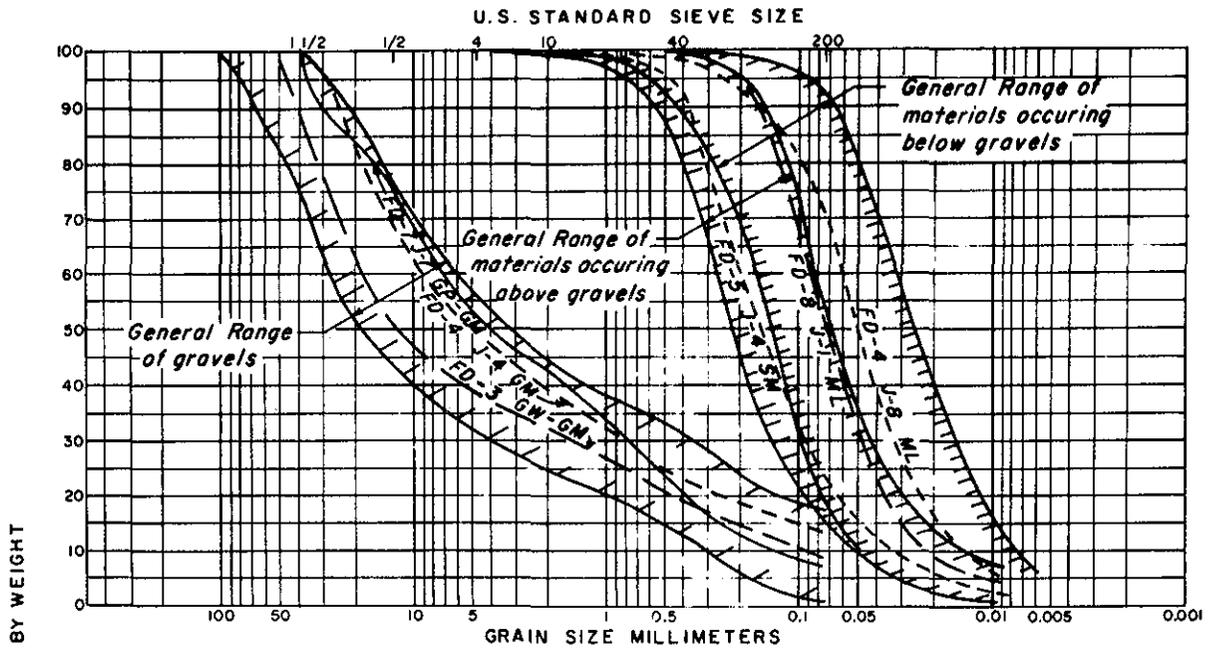


LEGEND FOR ENGINEERING LOGS

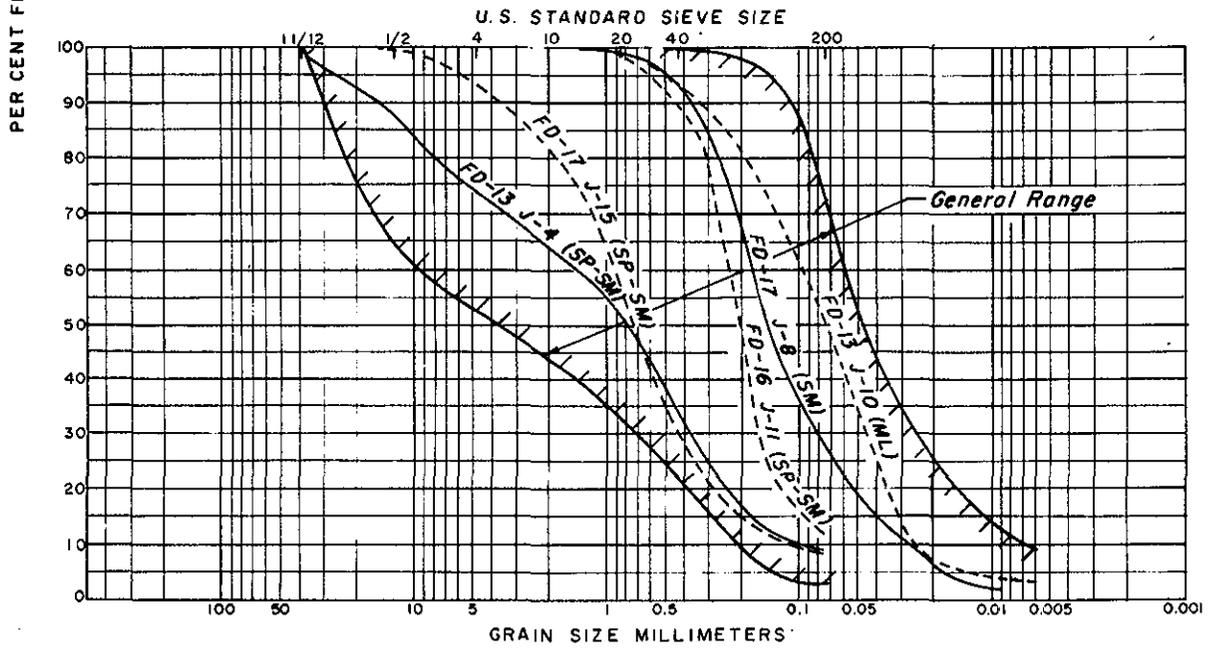
- D_{60} Effective grain size in millimeters
- 25 A single number following a soil component in the description of a soil, represents the percentage by weight, of that component in the soil as determined by a mechanical analysis
- (10-20) A range of numbers in parenthesis following a soil component in the description of a soil, represents the estimated limits between which lies the percentage by weight of that component in the soil determined by visual inspection
- SM Soil symbol, Unified Soil Classification System
- GR Gray
- BR Brown
- v very
- f fine
- m medium



CONNECTICUT RIVER FLOOD CONTROL
 ST. JOHNSBURY LOCAL PROTECTION
 ENGINEERING LOG PROFILE
 PASSUMPSIC AND SLEEPERS RIVERS, VERMONT



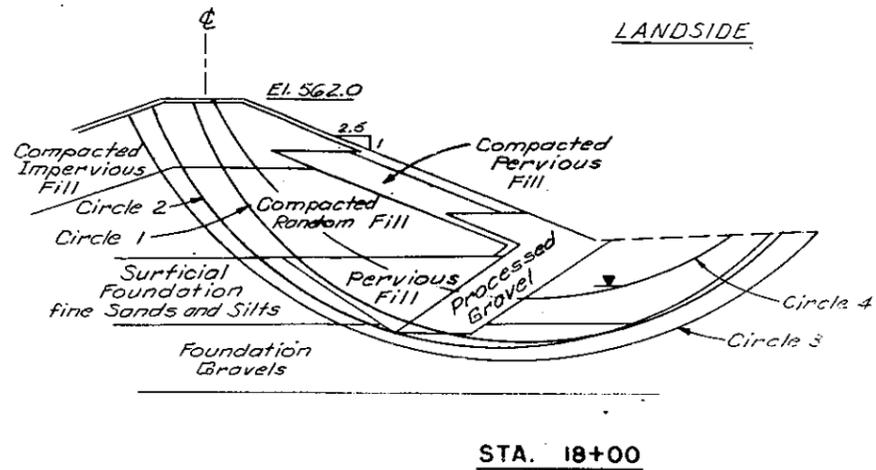
STA. 0+00 TO 22+60



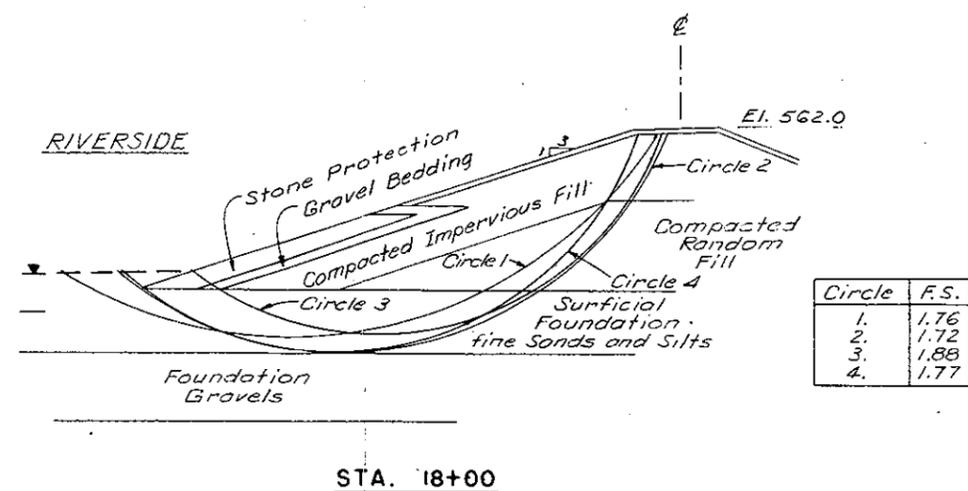
STA. 22+60 TO 26+95

GRADATION RANGES

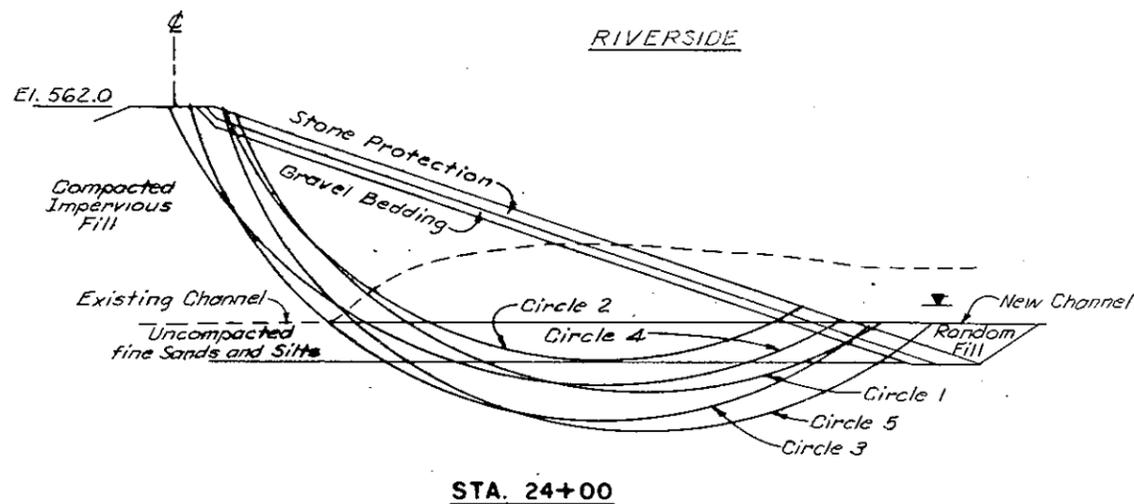
CONNECTICUT RIVER FLOOD CONTROL
ST. JOHNSBURY
 LOCAL PROTECTION
 SELECTED TEST DATA
 FOUNDATION
 PASSUMPSIC AND SLEEPERS RIVER, VERMONT



Circle	F.S.
1.	2.05
2.	1.94
3.	2.13
4.	2.05

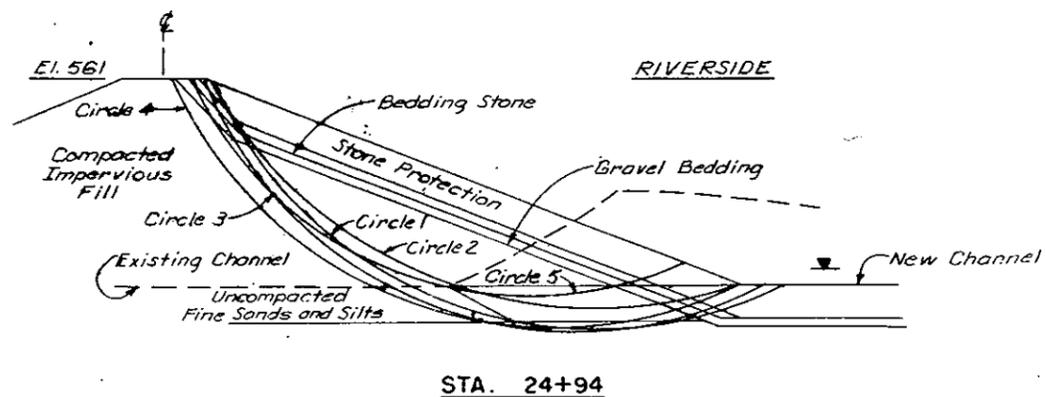


Circle	F.S.
1.	1.76
2.	1.72
3.	1.88
4.	1.77

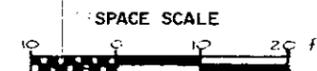


Circle	F.S.
1.	1.48
2.	1.59
3.	1.50
4.	1.53
5.	1.71

MATERIAL	UNIT WEIGHT (γ) PCF				SHEAR STRENGTH	
	γ _{dry}	γ _{sat}	γ _{sub}	γ _{moist}	φ	C, TSF
Compacted Random Fill	100	125	64	110	30°	0
Compacted Impervious Fill	120	140	78	130	30°	.1
Compacted Surficial fine Sands and Silts (Fdn.)	90	120	57	100	25°	0
Surficial fine Sands and Silts (Fdn.)	85	116	54	98	20°	0
Foundation Gravels, Pervious Fill, Processed Sand, Uncompacted Gravel Fill and Gravel Bedding	125	142	80	140	30°	0
Compact Gravel Fill and Processed Gravel	130	145	83	140	35°	0
Stone Protection	120	140	78	130	40°	0

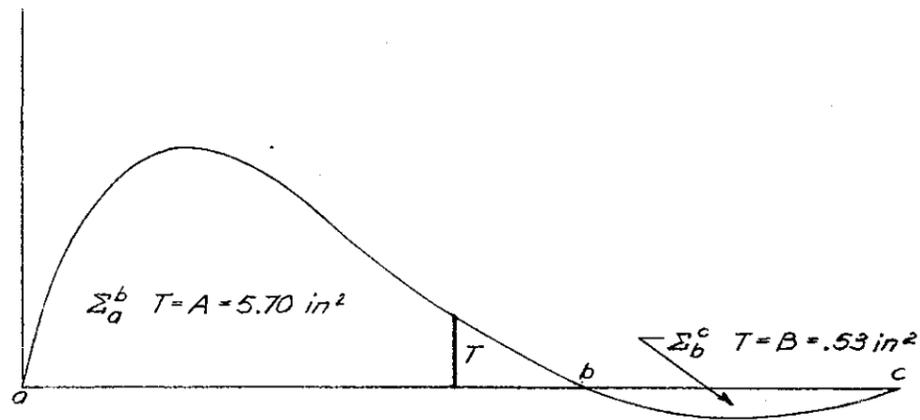


Circle	F.S.
1.	1.51
2.	2.10
3.	1.57
4.	1.70
5.	2.15

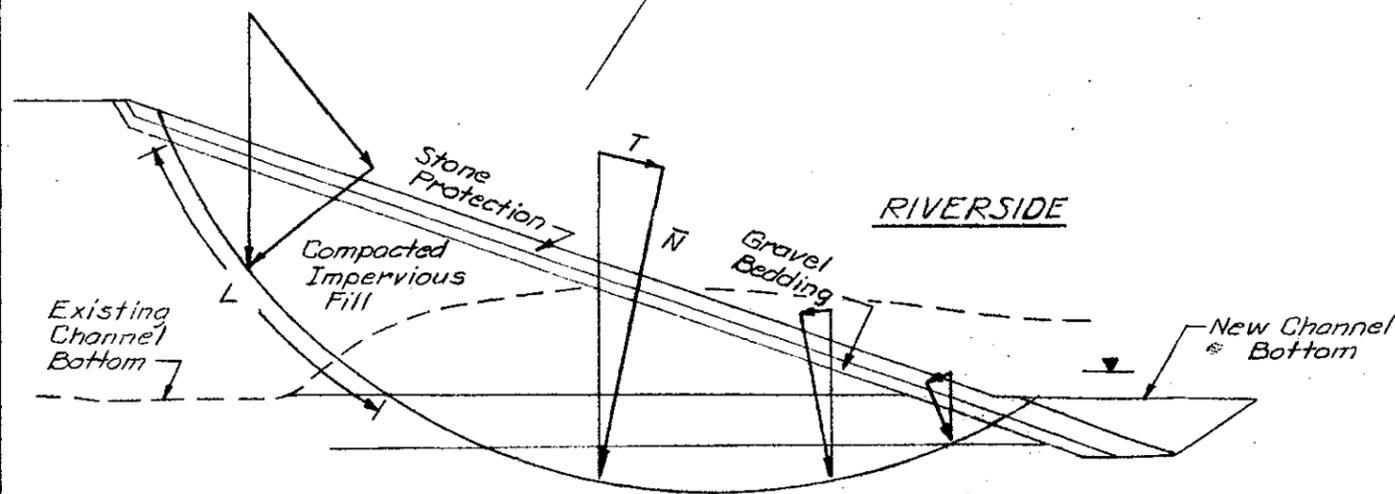
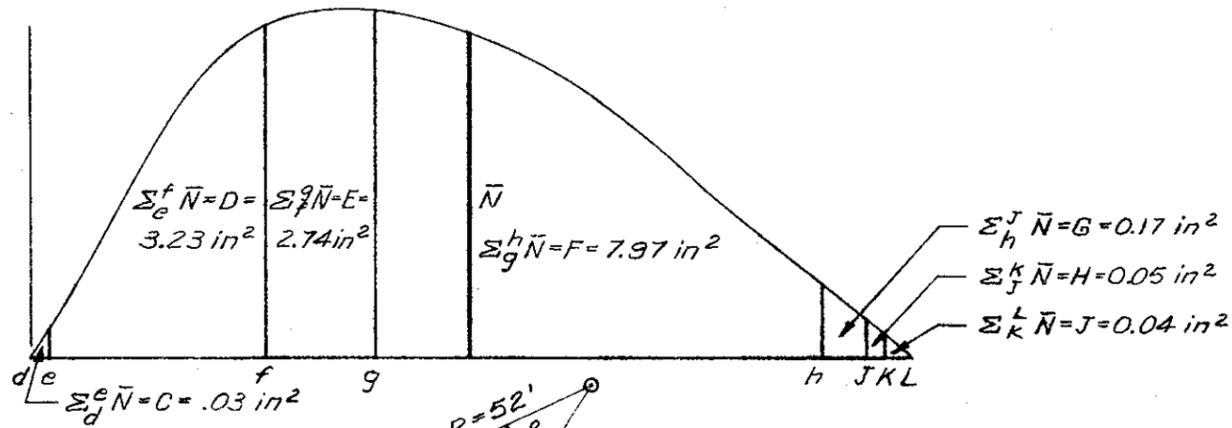


CONNECTICUT RIVER FLOOD CONTROL
 ST. JOHNSBURY LOCAL PROTECTION
 SUMMARY OF STABILITY ANALYSIS
 CONSTRUCTION CONDITION
 PASSUMPSIC AND SLEEPERS RIVERS, VERMONT

T
(Equals Tangential Pressure
x Sec θ)



N
(Equals Normal Pressure
x Sec θ)



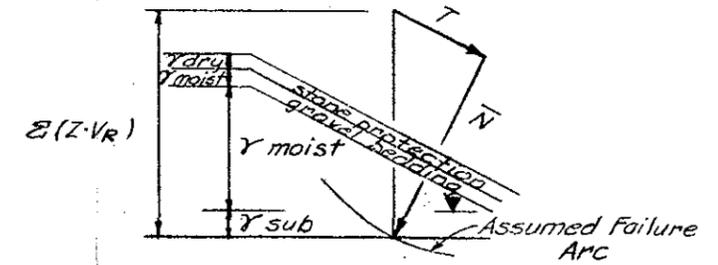
STA. 24+00

$K = \text{Vector Scale Conversion Factor}$
 $K = 10 \frac{\text{FT.}}{\text{IN.}} \times 10 \frac{\text{FT.}}{\text{IN.}} \times \frac{62.4 \text{ LBS.}}{50 \text{ FT.}} \times \frac{1 \text{ KIP}}{1000 \text{ LBS.}} = 6.24 \frac{\text{KIPS}}{50 \text{ IN.}}$

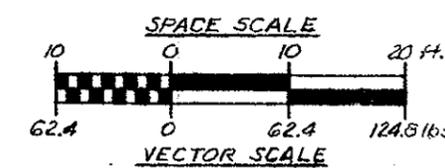
RESISTING FORCE = Summation $\bar{N} \tan \phi + cL$
 $\sum \bar{N} \tan \phi = (C+H) \tan 35^\circ + D \tan 30^\circ + (E+G) \tan 20^\circ + F \tan 25^\circ + J \tan 40^\circ$
 $= [(0.03+0.5) 0.7 + 3.23 \times 0.577 + (2.74+0.17) 0.364 + 7.97 \times 0.466 + 0.04 \times 0.839] K = 41.9K$
 cohesion, $c(L) = 0.2 \times 28 = 5.6K$
Total Resisting Force/Ft. Dike = 47.5K

DRIVING FORCE = Summation Tangential Forces
 $\sum T = (A-B) K = (5.70 - .53) 6.24 = 32.2K$
FACTOR OF SAFETY = $\frac{\text{Resisting Force}}{\text{Driving Force}} = \frac{47.5}{32.2} = 1.48$

WEIGHT VECTOR RATIO 62.4 lbs = 1.000	
MATERIAL	VECTOR RATIO (VR)
Stone Protection (dry)	120 ÷ 62.4 = 1.92
Stone Protection (sub)	78 ÷ 62.4 = 1.25
Gravel Bedding (moist)	140 ÷ 62.4 = 2.24
Gravel Bedding (sub)	80 ÷ 62.4 = 1.28
Compacted Impervious fill (moist)	130 ÷ 62.4 = 2.08
Compacted Impervious fill (sub)	78 ÷ 62.4 = 1.25
Foundation Soil (sub)	54 ÷ 62.4 = 0.87



TYPICAL VECTOR DIAGRAM

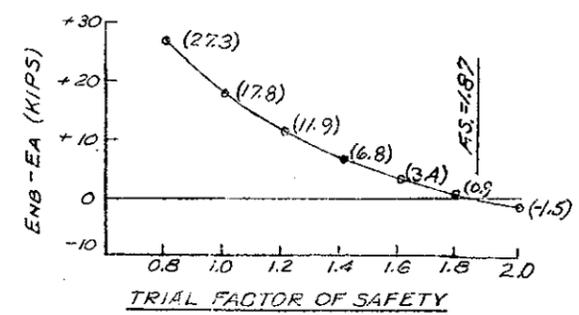
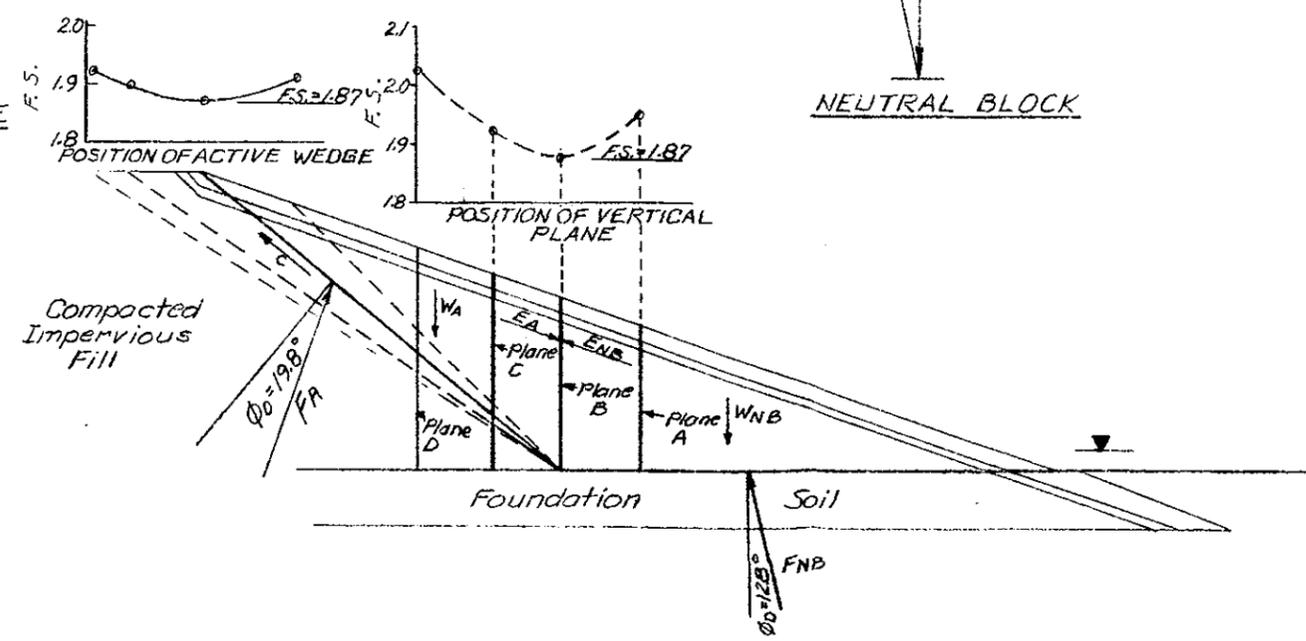
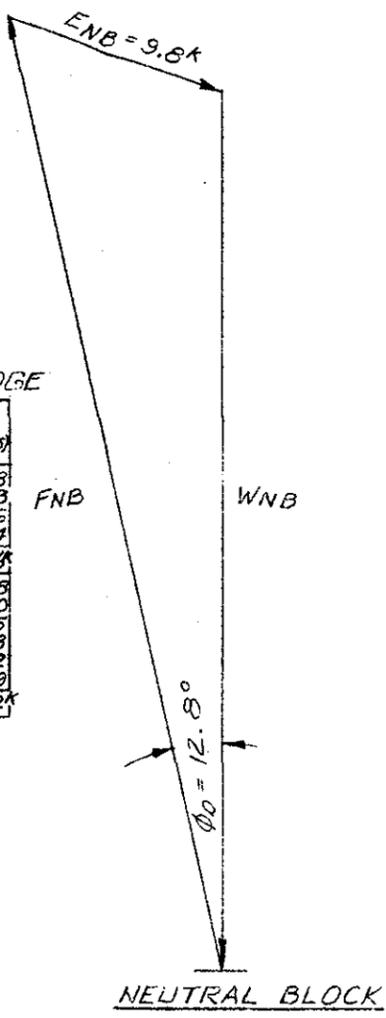
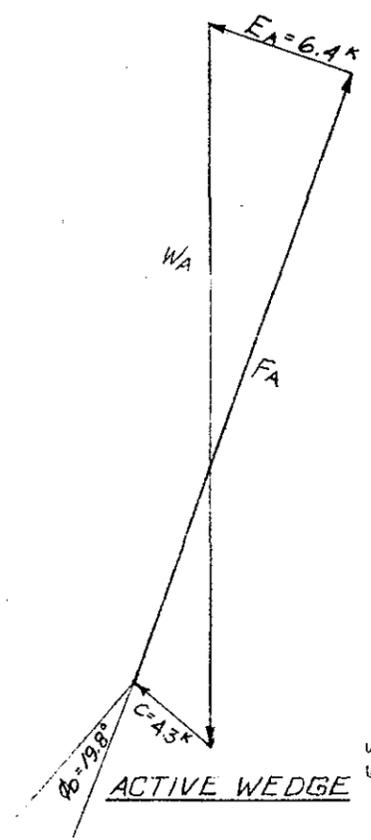


CONNECTICUT RIVER FLOOD CONTROL
 ST. JOHNSBURY LOCAL PROTECTION
 TYPICAL CIRCLE ANALYSIS STA 24+00
 CONSTRUCTION CONDITION
 CIRCLE NO. 1
 PASSUMPSIC AND SLEEPERS RIVER, VERMONT

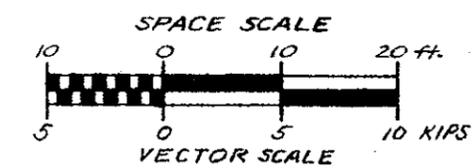
MATERIAL	ϕ	$\tan \phi$	Trial F.S.	$\frac{E_{NB} - E_A}{W_{NB}}$	ϕ_D
Impervious Fill	30°	.577	1.6	$\frac{5.77}{1.6} = 3.60$	19.8°
Foundation Soil	20°	.364	1.6	$\frac{3.64}{1.6} = 2.27$	12.8°

WEIGHT OF NEUTRAL BLOCK AND ACTIVE WEDGE

	MATERIAL		AREA * UNIT = WT	
			(FT ²)	(KIPS/FT) (KIPS)
ACTIVE WEDGE (WA)	Impervious Fill (sub)	1.6	.078	.13
	Impervious Fill (moist)	171.7	.130	22.33
	Gravel Bedding (moist)	28.3	.140	3.96
	Rock Protection (dry)	37.8	.120	4.54
WA = Weight of Active Wedge = 30.98K				
NEUTRAL BLOCK (WNB)	Impervious Fill (sub)	70.0	.078	5.48
	Impervious Fill (moist)	176.0	.130	22.80
	Gravel Bedding (moist)	35.0	.140	4.90
	Gravel Bedding (sub)	6.0	.080	.48
	Rock Protection (dry)	47.6	.120	5.72
	Rock Protection (sub)	7.5	.078	.59
WNB = Weight of neutral block = 37.52K				



STA. 24 + 00



CONNECTICUT RIVER FLOOD CONTROL
 ST. JOHNSBURY LOCAL PROTECTION
 TYPICAL WEDGE ANALYSIS
 CONSTRUCTION CONDITION
 FAILURE SURFACE B-2
 PASSUMPSIC AND SLEEPERS RIVER, VERMONT

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS				ATT. LIMITS		SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT		COMPACTION DATA			NAT. DRY DENSITY LBS/CUFT		OTHER TESTS		
					GRAVEL %	SAND %	FINES %	D ₁₀ MM.	LL	PL		TOTAL	- NO 4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	PVD LBS/CU FT	TOTAL	- NO 4	SHEAR	CONSOL.	PERM.
FD-1	550+	J-2R	0.3- 5.0	SM								15.0									
		J-3	5.0- 7.2	SM	0	76	24	.036													
		J-4R	5.0- 7.2	SM									23.6								
		J-6	10.0-15.0	GP-GM	68	26	6	.220													
		J-8	15.5-20.0	ML	0	27	73	.015					25.9								
		J-9	20.0-25.0	SM	0	75	25	.044					28.0								
		J-10	25.0-30.0	SM	31	44	25	.029													
		J-11R	25.0-30.0	SM							8.6	13.0									
FD-2	548+	J-5	10.0-12.6	SP-SM	44	48	8	.110													
		J-7	15.0-20.0	SM	0	81	19	.050													
		J-8	20.0-25.0	SM	0	74	26	.045													
		J-9R	20.0-25.0	SM									23.2								
		J-10	25.0-30.0	SM	0	73	27	.042													
		J-11R	25.0-30.0	SM								22.4									
FD-3	549+	J-3	4.8- 5.0	SM								28.0									
		J-4	5.0- 6.7	SM	0	62	38	.020													
		J-5	6.7-10.0	GP-GM	62	29	9	.095													
		J-9R	15.0-20.0	SM									29.6								
		J-10	20.0-25.0	SM	0	56	44	.032													
		J-11R	20.0-25.0	SM									31.7								
		J-13R	25.0-30.0	SM								30.9									
FD-4	549+	J-1	0.3- 5.0	SM	0	84	16					14.2									
		J-4	10.0-15.0	GM	52	35	13														
		J-7	20.0-25.0	ML									32.3								
		J-8	25.0-30.0	ML	0	30	70	.015													
		J-9R	25.0-30.0	ML									25.8								

PLATE NO. D-6

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS				ATT. LIMITS		SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT		COMPACTION DATA			NAT. DRY DENSITY LBS/CUFT		OTHER TESTS			
					GRAVEL %	SAND %	FINES %	D 10 mm.	LL	PL		TOTAL	- NO 4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO 4	SHEAR	CONSOL.	PERM.	
																						STANDARD
FD-5	548+ 1	J-3R	0.6- 5.0	SM								16.4										
		J-4	5.0- 8.3	SM	0	78	22	.035				20.3										
		J-6	10.0-15.0	GP-GM	65	29	6	.300														
		J-9	20.4-25.0	ML	0	28	72	.022														
		J-10R	20.4-25.0	ML									28.4									
		J-12R	25.0-30.0	ML									28.6									
FD-6	547+ 1	J-2	0.3- 5.0	ML	0	48	52	.017														
		J-3R	0.3- 5.0	ML								28.6										
		J-5R	5.0- 8.5	SM								31.2										
		J-7	10.0-15.0	GP-GM	59	32	9	.084														
		J-8	15.0-20.0	ML	0	18	82	.014														
		J-9R	15.0-20.0	ML								30.1										
		J-11R	20.0-25.0	ML								27.1										
		J-13R	25.0-30.0	ML								31.0										
		J-15R	30.0-32.2	ML								29.7										
FD-7	545+ 1	J-1	0.5- 5.0	SM	0	63	37	.030														
		J-2R	0.5- 5.0	SM								25.0										
		J-4	5.4- 7.2	ML																		
		J-5R	5.4- 7.2	ML								45.8										
		J-7	10.0-15.0	GP-GM	47	46	7	.150														
		J-9	20.0-25.0	ML	0	8	92	.0082														
FD-8	546+ 1	J-1	0.8- 5.0	ML	0	49	51	.021														
		J-2R	0.8- 5.0	ML								7.2										
		J-4	5.6- 8.2	SM	0	53	47	.021														
		J-7	10.0-15.0	GM	48	40	12															

PLATE NO. D-7

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS				ATT. LIMITS		SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT		COMPACTION DATA			NAT. DRY DENSITY LBS/CU FT		OTHER TESTS		
					GRAVEL %	SAND %	FINES %	D ₁₀ mm.	LL	PL		TOTAL	- NO 4	STANDARD		TOTAL	- NO 4	SHEAR	CONSOL.	PERM.	
														OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT						PVD * LBS/CU FT
FD-9	546+	J-3	1.9- 5.0	SM	0	83	17	.051				27.1									
		J-6	7.4- 9.4	SM	0	83	17	.041				26.4									
		J-12	21.8-25.0	ML								28.6									
		J-13	25.0-30.0	ML	0	41	59	.032													
		J-14R	25.0-30.0	ML								30.9									
FD-10	546+	J-1	0.8- 5.0	SM	0	59	41	.030													
		J-2R	0.8- 5.0	SM								20.9									
		J-4R	5.0- 8.0	SM								29.4									
		J-6	10.0-15.0	SM	0	87	13	.050				36.0									
		J-11	25.6-30.0	ML	0	26	74	.018				29.4									
FD-11	551+	J-2R	0.4- 5.0	SM							15.9										
		J-3	5.0- 8.3	SM	0	73	27	.035				25.4									
		J-5	10.0-10.2	GP-GM	59	35	6	.260													
FD-12	545+	J-2R	0.2- 5.0	SM							12.7	17.2									
		J-3	5.0- 9.2	ML	0	48	52	.016				35.0									
		J-5	10.0-15.0	GP	58	39	3	.200													
		J-7	17.0-20.0	ML	0	38	62	.012				29.9									
FD-13	543+	J-1	0.6- 3.5	SM							40.2										
		J-2	3.5- 4.5	SP	8	90	2	.220													
		J-4	5.0-10.0	SP-SM	27	65	8	.110													
		J-7	15.0-20.0	SM								17.6									
		J-9R	20.0-25.0	ML								31.3									
		J-11R	25.0-30.0	ML	0	50	50	.026				28.1									

PLATE NO. D-8

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS				ATT. LIMITS		SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT		COMPACTION DATA				NAT. DRY DENSITY LBS/CUFT		OTHER TESTS		
					GRAVEL %	SAND %	FINES %	D ₁₀ MM.	LL	PL		TOTAL	- NO 4	STANDARD		TOTAL	- NO 4	SHEAR	CONSOL.	PERM.		
														OPT WATER % DRY WT	MAX. DRY DENS. LBS/CU FT						* PVD LBS/CU FT	
FD-14	546+	J-2R	0.8- 5.0	SM								25.0										
		J-4	7.5-10.0	SM	0	64	36	.021														
		J-5	10.0-11.5	SM								47.0										
		J-8	15.0-20.0	GP-GM	51	42	7	.095														
FD-15	550+	J-5	10.0-15.0	SM	0	51	49	.016														
		J-6R	10.0-15.0	SM								31.1										
		J-8	15.5-18.5	ML								41.1										
		J-10	20.0-25.0	GM	46	37	17															
		J-11	25.0-26.0	SM								14.7										
		J-12	26.0-27.0	SM								22.7										
		J-13	27.0-29.0	SM	7	82	11															
		J-14	29.0-30.0	SM								19.8										
FD-16	553+	J-3R	1.5- 5.0	SM								12.8										
		J-4	5.0-10.0	SM	3	68	29	.021														
		J-5R	5.0-10.0	SM								20.2	21.0									
		J-6	10.0-14.0	ML	0	34	66	.071														
		J-7R	10.0-14.0	ML								27.8										
		J-11	16.5-20.0	SP-SM	0	89	11															
		J-14	25.0-30.0	SP-SM	1	91	8	.090														
FD-17	551+	J-5	5.0-10.0	SM	6	59	35	.020														
		J-7	10.5-15.0	SM								31.8										
		J-8	15.0-17.5	SM	0	74	26	.030														
		J-12	25.0-30.0	SM	0	50	50	.030														
		J-15	32.5-35.0	SP-SM	8	85	7	.120														
		J-19	42.0-44.5	SM								23.9										
		J-21	45.0-48.5	SP-SM	3	86	11	.065				11.3	14.6									
		J-22	48.5-50.0	SM								26.1										

PLATE NO. D-9

APPENDIX E

STRUCTURAL DESIGN

APPENDIX E

STRUCTURAL DESIGN

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APPENDIX E

STRUCTURAL DESIGN

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APPENDIX E

STRUCTURAL DESIGN

1. PURPOSE AND SCOPE. - This section presents the design criteria, basic data, assumptions and the procedure used in the structural design of floodwalls, railroad gate structure, and pumping station. Typical computations, including stability analyses, are included showing the maximum loading conditions and design of critical sections.

2. DESIGN CRITERIA.

a. General. - All working stresses conform to those specified in the Engineering Manual EM 1110-1-2101 dated 1 November 1963. General loading conditions, design assumptions and other design criteria are based on the following applicable parts of the Engineering Manual for Civil Works: Standard Practice for Concrete (Part CXX, October 1953), Structural Design of Pumping Stations (EM 1110-2-3104, dated June 1958), Retaining Walls (EM 1110-2-2502, dated May 1961), and Wall Design (Part CXXV, Chapter 1, change 2, dated 15 March 1961).

b. Concrete. - Concrete working stresses will be in general accordance with ACI Standard Building Code Requirements for reinforced concrete, using concrete with a minimum ultimate compressive strength of 3,000 lbs per square inch.

Flexure (Extreme fiber stresses in comp.) P.S.I.	
Roof and Floor Systems of Pumping Station	1350
All other concrete	1050

c. Reinforcement.

(1) Grade and Working Stresses. - All reinforcement in the structures, including temperature and shrinkage reinforcement was designed for the working stresses of new billet steel, intermediate grade, deformed bars which is 20,000 p.s.i. in flexural tension. The reinforcement shall conform to the requirements of Federal Specification QQ-S-632, Type II, Grade C and to ASTM A-305-56T.

(2) Spacing. - The clear distance between parallel bars will not be less than $1\frac{1}{2}$ times the diameter of round bars except

that in no case will the clear distance between parallel bars be less than 1-inch, or $1\frac{1}{2}$ times the maximum size of the coarse aggregate.

(3) Minimum Cover for Reinforcement.

<u>Item</u>	<u>Min. Cover (Inches)</u>
Interior slabs	3/4"
Exposed concrete (water or atmosphere) below grade	3 "
Bottom of base slab	4 "

(4) Splices. - All splices shall be in accordance with the ACI Standard Building Code as set forth in Table 14c of Reinforced Concrete Design Handbook, ACI Publication SP-3.

(5) Temperature and Shrinkage Reinforcement. - Temperature and shrinkage reinforcement will be provided where the main reinforcement extends in only one direction. Such reinforcement will provide for a ratio of steel area to concrete area (bd) of 0.002 with a minimum of 0.0012 in each face up to a maximum of #6 bars at 12" cc.

d. Structural Steel. - Structural steel is designed for the working stresses of bridge and building steel with a yield point of 36,000 p.s.i. minimum (A36). Design conforms to the latest specification for the Design Fabrication and Erection of Structural Steel for Buildings and to EM 1110-1-2101. Basic working stresses were obtained from Table B (Hydraulic Structures) except the structural steel in the pumping station which was designed by the AISC Code using a 22,000 lbs per sq. in. basic working stress.

e. Increase in Normal Working Stresses. - Allowable working stresses are increased 33-1/3% only where wind loads are used.

f. Castings and Misc. Items. - Hinge shoes for structural gates will be of cast steel conforming to Federal Specifications QQ-S-681d. The hinge bushings and washers will be a self-lubricating bronze and the hinge pins of a corrosion resistant steel.

g. Wood Piles. - Piles supporting the railroad gate structure will be dense close-grained Southern Yellow Pine or Pacific Coast

Douglas Fir conforming to the requirements of Federal Specification MM-P-371a for "Piles; Wood", Type I, Class C, rough peeled. The minimum tip diameter of any length of pile will be 8". Piles will be treated and will be driven to obtain a minimum friction capacity of 20 tons, and will be approximately 30 feet in length.

3. BASIC DATA AND ASSUMPTIONS.

<u>a. Controlling Elevations.</u>	Feet Above m.s.l.
Top of Flood Walls	561.0
Top of Rail at Railroad Gate	554.67
Operating Floor of Pumping Station	550.5
Crane Rail of Pumping Station	562.25

b. Loads.

(1) Dead Loads.

Concrete	150	p.s.f.
Steel	490	p.s.f.
Soil, dry	90	p.c.f.
Soil, moist	100	p.c.f.
Soil, saturated	120	p.c.f.
Soil, submerged	57	p.c.f.

(2) Live Loads. The following live loads are used:

Water	62.5	p.c.f.
Wind	30	p.s.f.
Design load on roof slab	40	p.s.f.
Crane load	2	tons
Operating floor slab	225	p.s.f.
Operating floor beams	225	p.s.f. plus equip. loads

c. External Water Pressure. - Hydraulic pressure under flood condition is assumed to act over the entire area in question under the full head on the riverside heel and varying by the creep method to zero at the ground line on the landside.

d. Earth Pressure. - Earth pressures are determined in general accordance with EM 1110-2-2502. Retaining walls dated 29 May 1961.

e. Earthquake Forces. - Earthquake forces are considered to be of no consequence on these structures and have been neglected.

f. Frost Protection. - All structures will have a minimum of 5'-0" cover for frost protection.

g. Location of Resultant and Sliding. - The location of resultant and the sliding factor are not critical under the structures. The railroad gate structure will have a pile foundation such that the resultant of all forces will produce a negligible amount of tension in any pile and the compression value will be well within the pile capacity. The resultant of forces acting on the pumping station will fall close to the centroid of the base area.

h. Allowable Soil Bearing. - The allowable soil bearing pressure is 4,000 lbs per sq. ft. under the pumping station.

4. I-WALL.

A short length of I-wall will be utilized to tie the railroad gate structure into the dike on the east side and into high ground on the west side. This wall will have a maximum projection above ground on the riverside of 10 feet while on the landside, there will be a small berm and ground elevation approximately two feet higher than riverside. To fit the Mathatron Computer program available, the wall was assumed to have a 10 ft. projection above ground on either side. It was assumed loaded with water to the full height of the wall on riverside and to ground surface on the landside. The design section will consist of MZ-38 having a 27 ft. penetration. The exposed portion of the wall will be of reinforced concrete having a minimum width of 1'-6" at the top and 2'-6" at 5'-0" below grade.

5. RAILROAD GATE STRUCTURE.

a. General. - This structure closes off the railroad consisting of three tracks and requiring a clear opening of 58'-0".

The structure will require two gate leafs with an A-frame support on each leaf that must be located between tracks. The support for the A-A-frame must be recessed so as to not interfere with normal traffic of the railroad. The top of the abutment housing the gate will be at elev. 564.0 with the top of gate 1'-0" below. The actual gate leaf height will be 8'-2" + which permits a clearance over the rails of 2-inches. The bottom of the base slab will be at elev. 545.0 and the structure will be supported on battered wood piles.

b. Loading Conditions. - The gate structure was investigated for the following loading conditions:

- (1) Case I - Dead load of concrete only.
- (2) Case II - Dead load of concrete, earth and gate.
- (3) Case III - Dead loads plus train wheel loads and gates jacked in the pockets.
- (4) Case IV - Flood condition with water to top of gate.

c. Concrete Abutment Design. - Stability requirements were satisfactory for all conditions of loading. The structure was analyzed as a series of longitudinal strips assuming them acting as beams in an elastic foundation. Because the structure is on piles, the foundation modulus was assumed as 120,000. End reactions are taken by the abutments which are designed for the reaction loads. Reinforcement requirements in the transverse direction are minimum. Computations included in the appendix show the printout obtained from a computer program based on L. P. Popov's method of "Successive Approximations for Beams on an Elastic Foundation" and as run on the IBM 7044 computer. Computations included are for a single strip at the toe under Case IV loading. Pile concentrations have been disregarded and base pressure assumed uniformly distributed. Other conditions of loading and strips are analyzed in a similar manner. Gate housing extension wall is not critically loaded and is designed as a retaining wall.

d. Steel Gate Design. - The 3/16 inch skin plate was designed to span continuously over three supporting horizontal wide flange members. The horizontal members are designed for the skin

plate reactions and span from the A-frame to the abutment end. The top and bottom members transfer the load into the hinge points. Torsional stress effects are considered negligible.

6. PUMPING STATION.

a. General. - The pumping station is 29'-6" by 15'-6" outside dimension at the operating floor. The superstructure will have brick walls, and concrete roof slab supported by structural steel framing. The substructure will be reinforced concrete. The pump chamber is 19'-0" by 12'-6" with intake chamber 6'-0" wide. The operating floor is at elev. 550.5 and bottom elev. of base slab is 537.0.

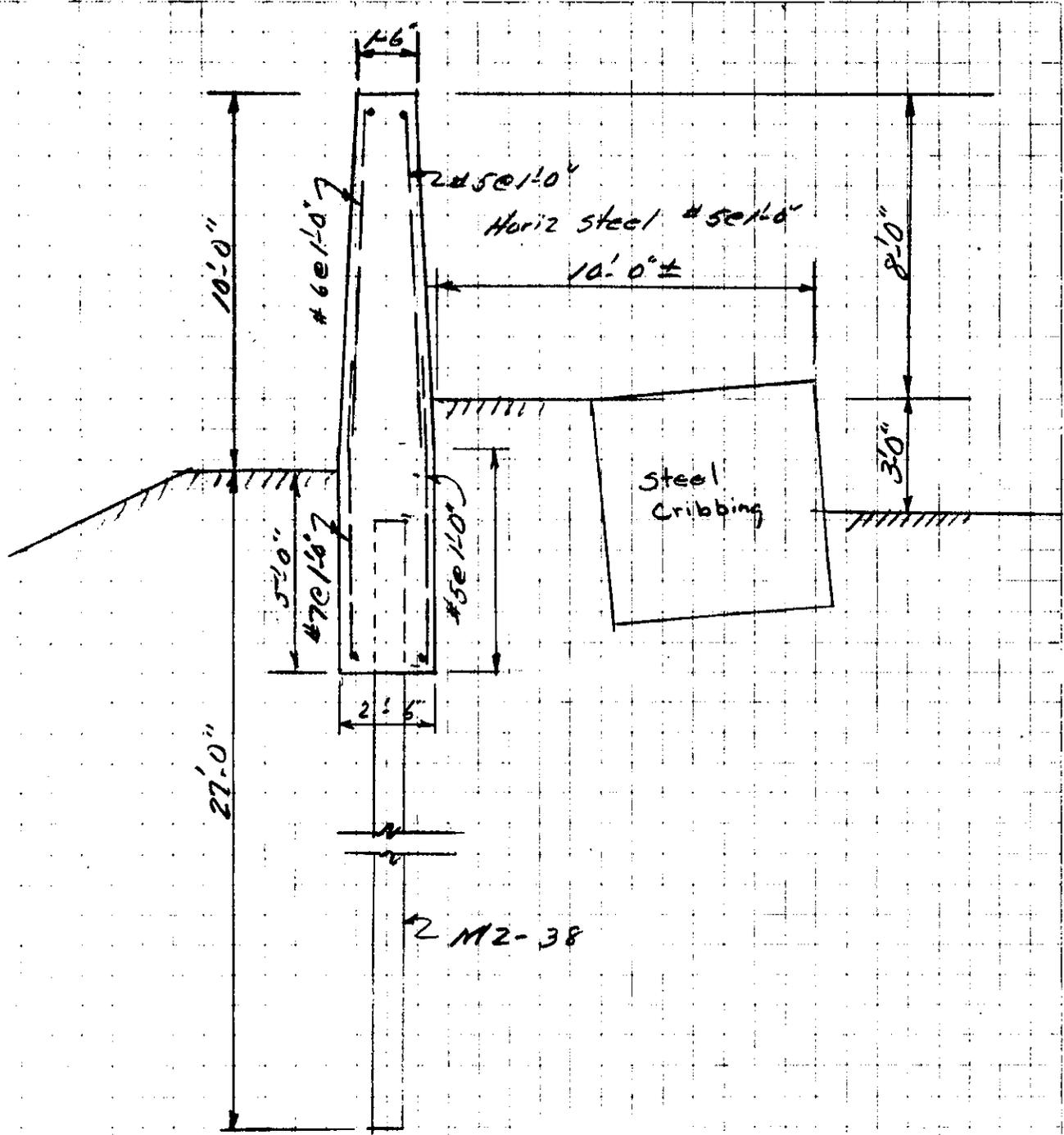
b. Stability. - Stability is not a problem, but the location of the centroid of the loads and centroid of the base area was determined in order to obtain the base pressures.

c. Design. - The roof slab is pitched in one direction and will be a 6-inch minimum concrete slab obtaining support on structural steel spandrel beams with one interior cross beam. The slabs are designed for two way action. The steel spandrel beams are supported on steel columns that are also designed to take the crane loads. The floor slab is slab and beam construction designed for a live load of 225 lbs per sq. ft. The substructure was analyzed as a continuous frame.

SUBJECT *St. Johnsbury Vt.*

COMPUTATION *F Type Wall*

COMPUTED BY *H.E.W.* CHECKED BY _____ DATE *Oct 1966*



SUBJECT St. Johnsbury Vt.
COMPUTATION I Type Wall
COMPUTED BY H.E.W CHECKED BY _____ DATE Oct. 1966

CANTILEVER SHEET PILE WALL ST. JOHNSBURY, VT.

DESCRIPTION:---THIS PROGRAM FINDS THE MINIMUM PENETRATION. OR GIVEN THE PENETRATION FINDS THE PASSIVE P, MAX. M, AND S OF SHEET PILING

LOADING:---TRIANGULAR WATER LOAD TO TOP OF WALL ON ONE SIDE PLUS A CONCENTRATED LOAD. WATER ON OTHER SIDE ASSUMED AT A LOWER ELEV. GRADE IS THE SAME ON BOTH SIDES.

INSTRUCTIONS:---CONTROL & PROGRAM MODE @ AUTO OUTBOARD READER OFF

FIND MINIMUM PENETRATION.

H=EXPOSED HEIGHT OF WALL =10.0
P=CONCENTRATED LOAD =0
Y=DIST OF CONC. LD. TO GR=0
PP=PASSIVE PRESSURE (SUB E)=134
PA=ACTIVE " (SUB E)=19
W=WEIGHT OF WATER =62.5
Q=DIFFERENTIAL HEAD =10.0
X=ASSUME X=2H =30.0

DEPTH OF PENETRATION(FT) = 25.72
" " Z = 6.36

GIVEN A DEPTH OF PENETRATION --- ENTER FOLLOWING ITEMS:--((

X=DEPTH OF PENETRATION =27.0
PP (ASSUME MAX) =134

PP = PASSIVE PRESSURE 130.56
Z = 6.86

FIND XO AND MAX. MOMENT IN THE SHEETING--- ENTER FOLLOWING ITEMS:--

ASSUMED XO (.33H)= 9.0
XO= (FEET) = 14.94
M FT LBS = 64851.53
REQD S (A36)FS=18000 = 43.23 Use MZ 38

SUBJECT ST. JOHNSBURY, V.T.

COMPUTATION RAILROAD GATE

COMPUTED BY EXM

CHECKED BY C.C.C.

DATE MAY, 1966

Soils Laboratory Data (c. Shufelt).

ALLOWABLE SOILS BEARING PRESSURE: 1000 psf Net.

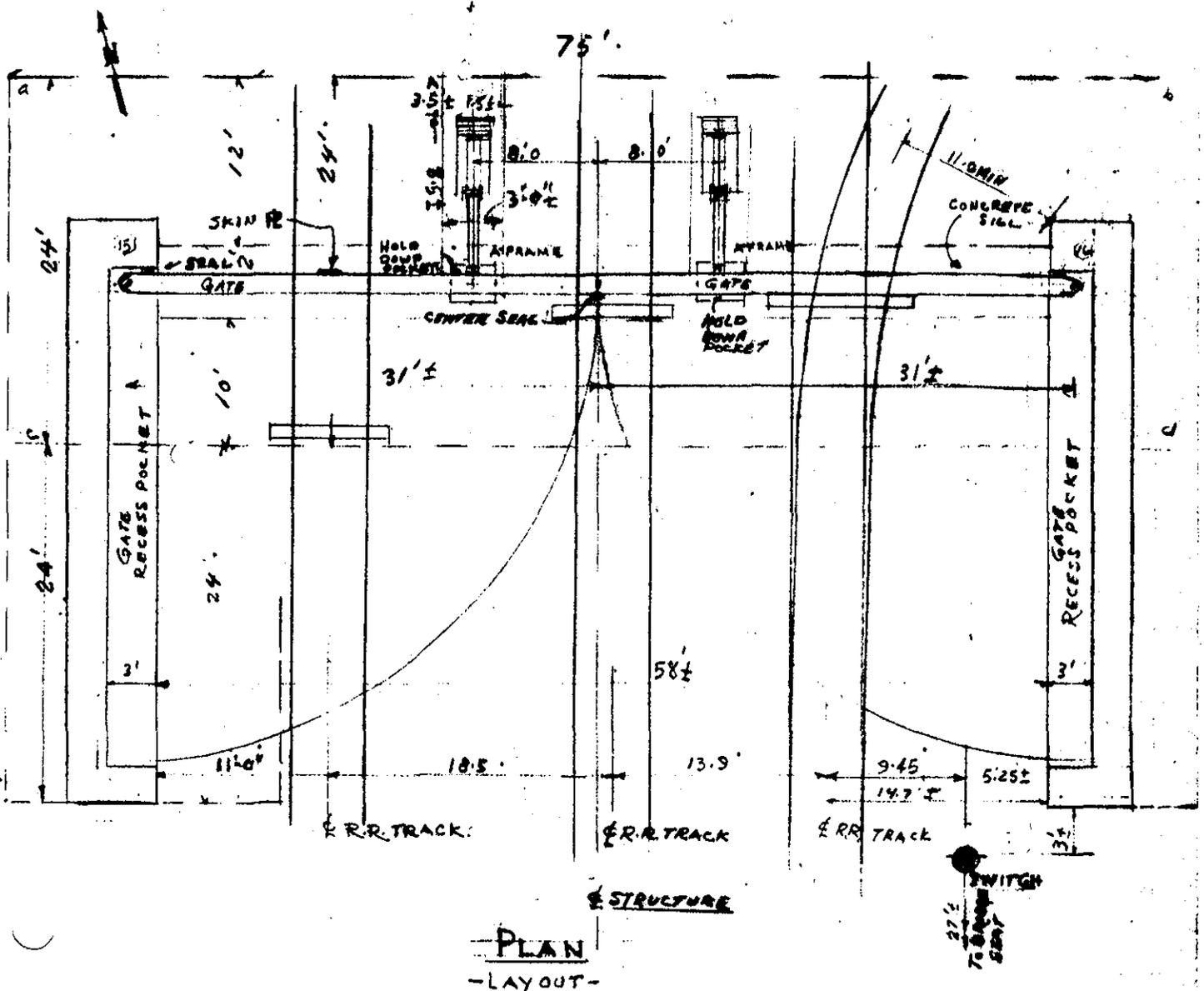
$\phi = 20^\circ$

$\delta = 90 \text{ pct}$
DRY

$\delta_{\text{sat}} = 120$

$\delta_{\text{sub}} = 57$

$\delta_{\text{moist}} = 100$



27 Sept 49

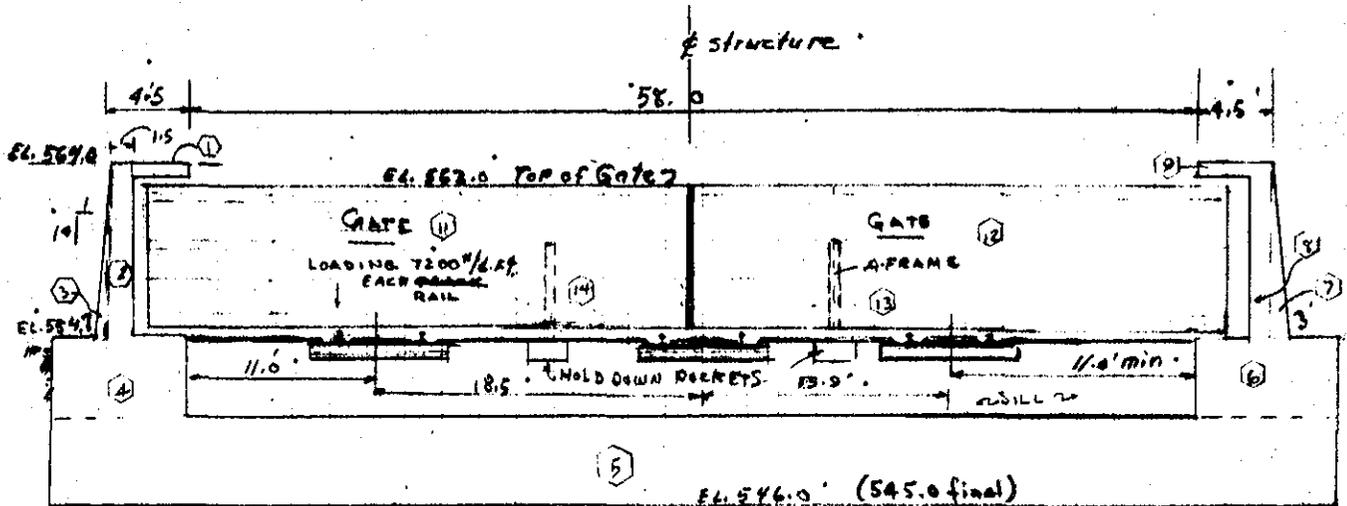
SUBJECT ST. JOHNSBURY, V.T.

COMPUTATION RAILROAD GATE

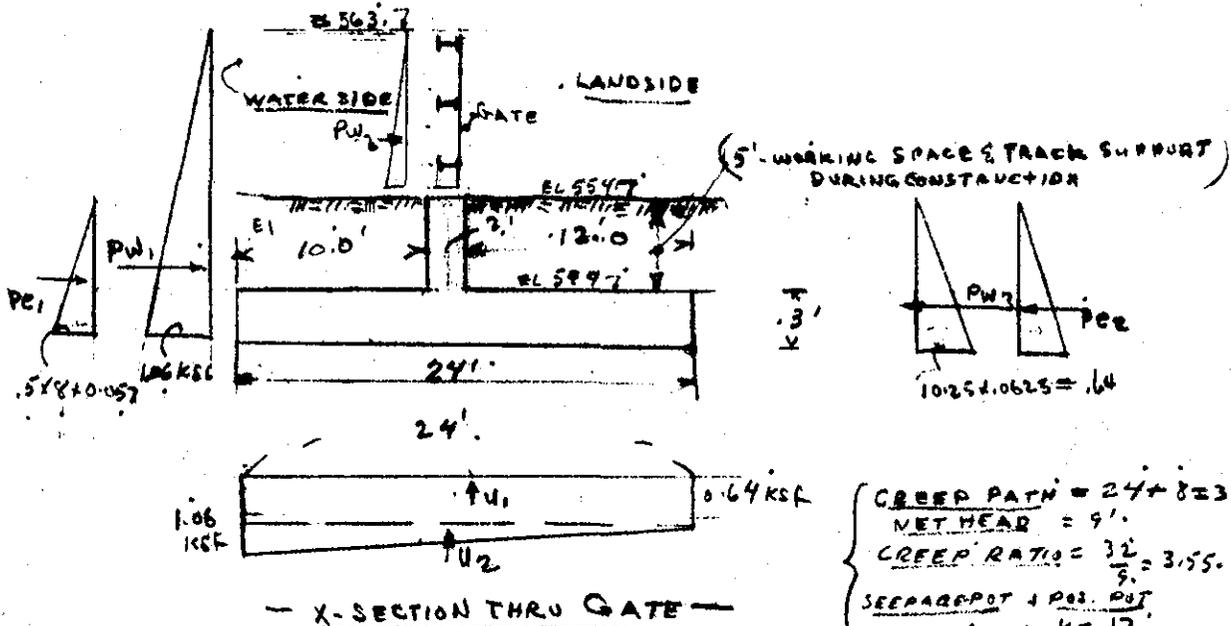
COMPUTED BY Ejm

CHECKED BY C.C.C.

DATE MAY 1966



X-SECTION THRU TRACKS AT GATE



X-SECTION THRU GATE

$$\begin{aligned} \text{CREEP PATH} &= 24 + 8 = 32 \\ \text{NET HEAD} &= 9' \\ \text{CREEP RATIO} &= \frac{32}{9} = 3.55 \\ \text{SEPARATION + POS. DIST.} & \\ q &= 4 + 8 = 17' \\ b &= 4 \times \frac{8}{32} + 8 = 10.25' \end{aligned}$$

27 Sept 49

MARK DMS

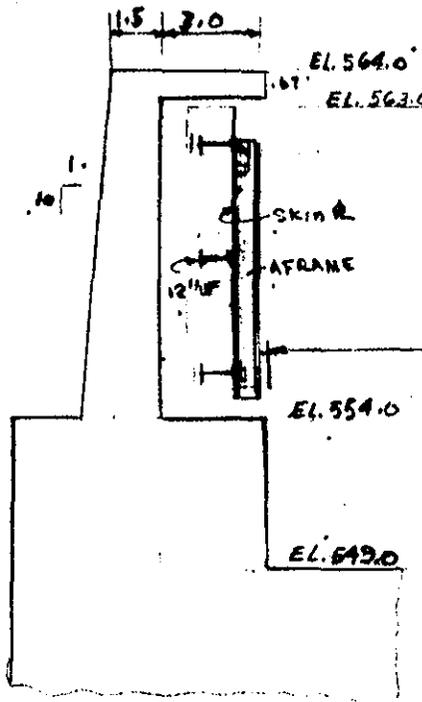
SUBJECT ST. JOHNSBURY, V.T.

COMPUTATION RAILROAD GATE

COMPUTED BY EJm

CHECKED BY C.C.C.

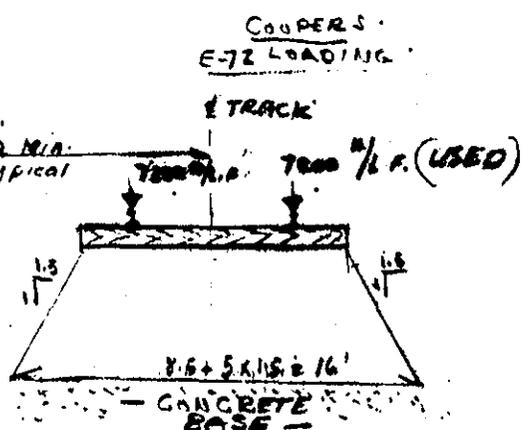
DATE MAY 1966



ASSUMED WIND OF GATE:

- $\frac{1}{4}'' R = 85'$
- $4-16'' = 165'$
- Bracing & Drag = $\frac{80'}{330' \text{ say } 350' /}$
- A FRAME - SAY 400 # TOTAL

TYPICAL LOAD ON TRACK



FROM RAILROAD ENG. ASSOCIATION MANUAL = 3 TRACKS = AREA, P. 8-2-3.

LOAD 2' FULL L.L. ADD $\frac{1}{2}$ LL. REMAINING TRACKS FOR DESIGN ONLY.

FOR STABILITY USE: TOTAL LOAD 3 TRACKS =

$W_{TOTAL} = 29 \times 3 \times 14.7 = 1270 \text{ K}$

$24' \times 3 \times 2 \times 7.2 = 1036.8 \text{ K}$

E-72 COOPER LOADING

AXIAL LOAD 72,000 #
 $72000 \div 15 = 36000 \text{ #/wheel}$

wheels 5' apart U.L. wheels $36,000 \div 5 = 7200 \text{ #/L.F./RAIL}$
 Considering Engines on Track. CONSERVATIVELY

SUBJECT ST. JOHNSBURY VT.

COMPUTATION RAILROAD GATE.

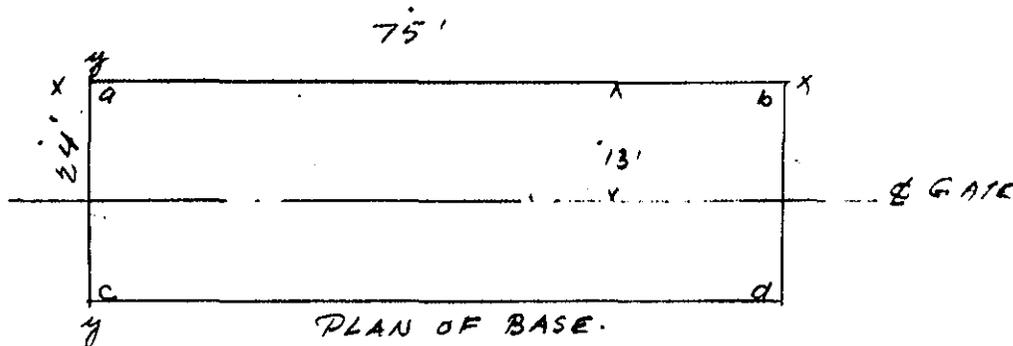
COMPUTED BY Exm

CHECKED BY C.C.C.

DATE June 1966

STABILITY

- CASE I: DEAD LOAD - CONCRETE ONLY.
- CASE II: DEAD LOAD - EARTH & GATE LOAD ADDED.
- CASE III: TRAINS ON TRACKS, NO WATER, GATE IN POCKET.
- CASE IV: FLOOD STAGE, WATER EL. 563.00, GATE ACROSS TRACKS, IN FUNCTION.



AREA OF BASE = $75 \times 24 = 1800'$

$I_{xx} = \frac{75 \times 24^3}{12} = 86,400 \text{ ft}^4$

$I_{y-y} = \frac{24 \times 75^3}{12} = 843,750 \text{ ft}^4$

CASE I

ITEM	FACTORS	↓	↑	→	←	ARM	→ Mom ←
1' & 9"	0.15' x 0.67' x 3' x 12' x 2'	7.25'				18.0'	130.5'
2' & 8"	0.15' x 1.5' x 12' x 10' x 2'	54.2'				18.0'	975.0'
3' & 7"	0.15' x 1' x 10' x 12' x 0.5' x 2'	18.0'				18.0'	324.0'
4' & 6"	0.15' x 8.5' x 5' x 15' x 2'	191.0'				16.5'	3150.0'
5' Base	0.15' x 1800' x 3'	810.0'				12.0'	9720.0'
SOIL	0.15' x 5' x 2' x 58'	87.0'				13.0'	1130.0'
15' & 16"	0.15' x $\frac{45 \times 55}{2}$ x 3' x 11' x 2'	49.0'				5.5'	269.5'

$\Sigma V = 1216.45'$

$\Sigma M = 15699.0'$

$X = \Sigma M \div \Sigma V = 15699.00 \div 1216.45 = 12.90 > \frac{24}{3} = 8 < 16$

$e = 0.90$

SOIL BEARING PRESSURE = $f_B = \frac{P}{A} \pm \frac{Mc}{I} = \frac{1216.45}{1800} \pm \frac{1216.45 (0.90) (12.00)}{86,400} =$

$0.68 \pm 0.15 = \begin{cases} 0.83 \text{ ksf} @ cd \\ 0.53 \text{ ksf} @ ab \end{cases}$

SUBJECT ST. JOHNSBURY VT.

COMPUTATION RAILROAD GATE.

COMPUTED BY Ejm

CHECKED BY C.C.C.

DATE June 1966

CASE II - DEAD LOAD OF CONCRETE - EARTH & GATE ADDED.
- GATES IN POCKETS, BUT BEFORE JACKING.

ITEM	FACTORS	↓	↑	→	←	ARM	Mab
CONCRETE COMPUTED IN CASE I.		1216.45					15,699.0
E1	0.10 X 10 X 58 X 5	290.0				19.00	5510.0
E2	0.10 X 3 X 52 X 5	78.0				10.50	819.0
E3	0.10 X 5 X 9 X 75	337.5				4.50	1519.0
2 GATES	2 X 11 KIPS	22.0				28.5	627.0
		$\Sigma V = 1943.95$				$\Sigma M = 24,174$	

$$x = \Sigma M \div \Sigma V = 24,174 \div 1943.95 = 12.44 > \frac{24}{3} < 2 \times 8 = 16$$

$$e = 0.44$$

$$SBP f_b = \frac{1943.95}{1800} \pm \frac{1943.95 (0.44) (12.00)}{86,400} = 1.08 \pm 0.12 = \begin{cases} 1.20 \text{ Ksf @ cd} \\ 0.96 \text{ Ksf @ ab} \end{cases}$$

CASE II A - GATES ACROSS TRACKS -

$\Sigma V = 1943.95$	$\Sigma M = 24,174$
- GATE: <u>22.00</u>	<u>- 627</u>
<u>1921.95</u>	<u>23,547.0</u>
ADD GATE	
ACROSS TRACKS	
350 X 2 X 3 = 22.0	X 13 = 286.0

$$\text{Total } \Sigma V = 1943.95 \quad \Sigma M = 23,833.0$$

$$x = 23,833 \div 1943.95 = 12.26$$

$$SBP = \frac{1943.95}{1800} \pm \frac{1943.95 (126) (12)}{86,400} = 1.08 \pm 0.07 = \begin{cases} 1.15 \text{ Ksf} \\ 1.01 \text{ Ksf} \end{cases}$$

CASE III - TRAINS ON TRACKS, DRY CONDITION, GATES IN POCKETS
- JACKED -

ITEM	FACTORS	↓	↑	→	←	ARM	Mab
FROM CASE II A		1921.95					23,547.0
TRAINS ON TRACKS	24 X 3 X 2 X 7.2	1036.8				12	12,441.6
GATE	2 (11.0) X 2	<u>11.0</u>				13	<u>143.0</u>
		<u>2969.75</u>					<u>36,131.6</u>

$$x = \Sigma M \div \Sigma V = 36,131.6 \div 2969.75 = 12.17 \quad e = 0.17$$

$$SBP = \frac{2969.75}{1800} \pm \frac{2969.75 (0.17) (12.0)}{86,400} = 1.65 \pm 0.07 = \begin{cases} 1.72 \text{ Ksf @ cd} \\ 1.58 \text{ Ksf @ ab} \end{cases}$$

SUBJECT ST. JOHNSBURY
COMPUTATION RAILROAD GATE
COMPUTED BY EJM CHECKED BY C.C.C. DATE JUNE 1966

CASE 1 - FLOOD STAGE WATER EL. 563.42 GATE ACROSS TRACKS IN FUNCTION

ITEM	FACTORS	↓	↑	→	←	ARM	← M ₄₀ →
Concrete	Computed CASE 1	216.45				13.4	15,699.0
F ₁ W.S.	0.057 x 10 x 58 x 5	165.3				19.0	3,141.0
F ₂ D.S.	0.12 x 3 x 58 x 5	104.5				10.5	10,910.0
F ₃ D.S.	0.12 x 5 x 9 x 75	40.40				4.5	1820.0
GATE	ACROSS TRACKS	22.0				13.0	286.0
W ₁	0.0625 x 13 x 11 x 58 ^{7.72}	520.0				18.5	9650.0
W ₂	0.0625 x 9 x 3 x 12 x 2 ^{rock}	40.5				18.0	729.0
W ₃	0.0625 x 15 x 3 x 9 ^{on lip}	25.4				16.5	487.0
PW ₁	0.0625 x 17 x 7.5 x 0.5			337		5.67	124
U ₁	0.64 x 24 x 75		1150			12.0	13,800
U ₂	0.42 x 24 x 75 x 0.5		377			16.0	6,040
PC ₁	0.57 x 8 x 0.5 x 75			137		2.67	387
PC ₂	0.12 x 8 x 0.5 x 75 x 1/2				145	2.67	366
		2498.1	1527	845	145		33,220
				474			22,117
				329			11,103

$\Sigma M \div \Sigma V = 11,103 \div 971 = 11.43$

$e = 657$

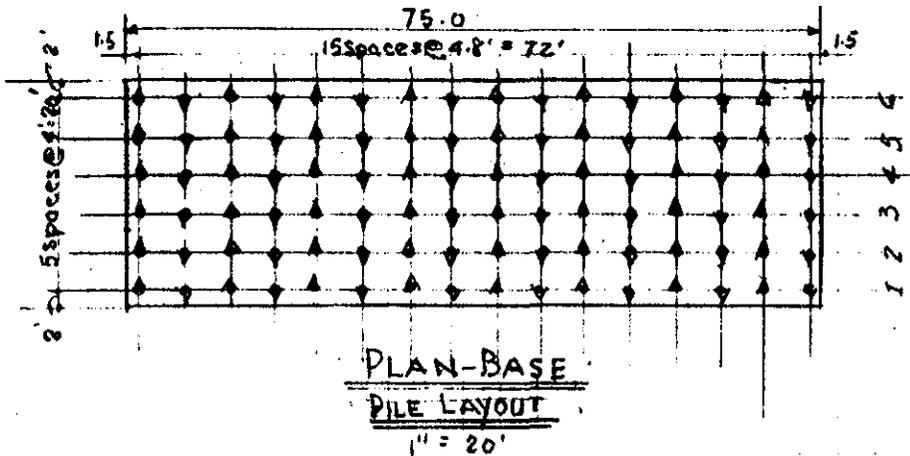
$SBP = \frac{971}{1800} \pm \frac{971(0.57)(12)}{86,400} = 0.54 \pm 0.07 = 0.61 \text{ KSF ab}$
 0.47 KSF cd

NOTES:
USE PILES.

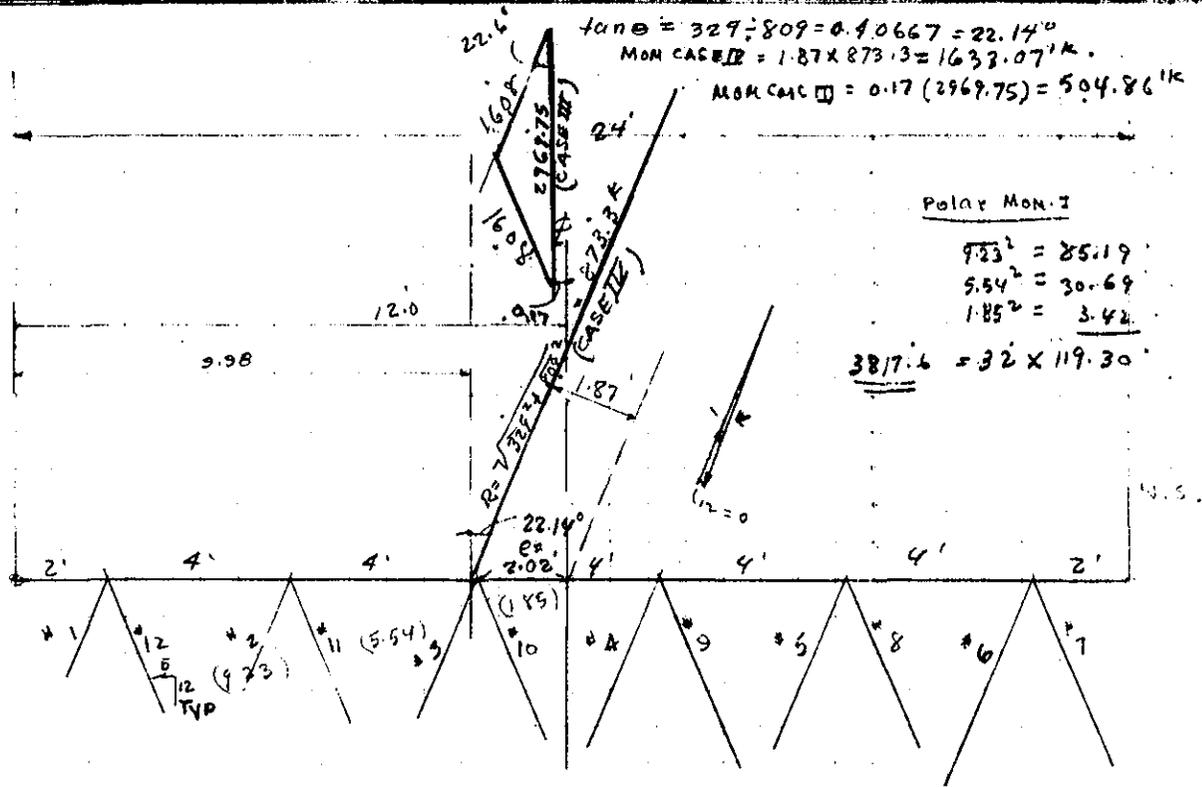
(207 WOODEN PILES PER SOILS LAB JUNE 9, 1966 30'-LONG.)
- FRICTION PILES -

SUBJECT ST. JOHNSBURY, VT.
COMPUTATION RAILROAD GATE.

COMPUTED BY Ejm CHECKED BY C.C.C. DATE JUNE 1966



16x6 = 96 PILES



CASE III	
PILE #	33.5
①	$\frac{1608 \cdot 1.2}{48} + \frac{504.9 (9.23)}{3817.6} = +34.7'k$
⑥	$33.5 - 1.2 = +32.3'k$
⑦	$+32.3'$
⑫	$+34.7'$

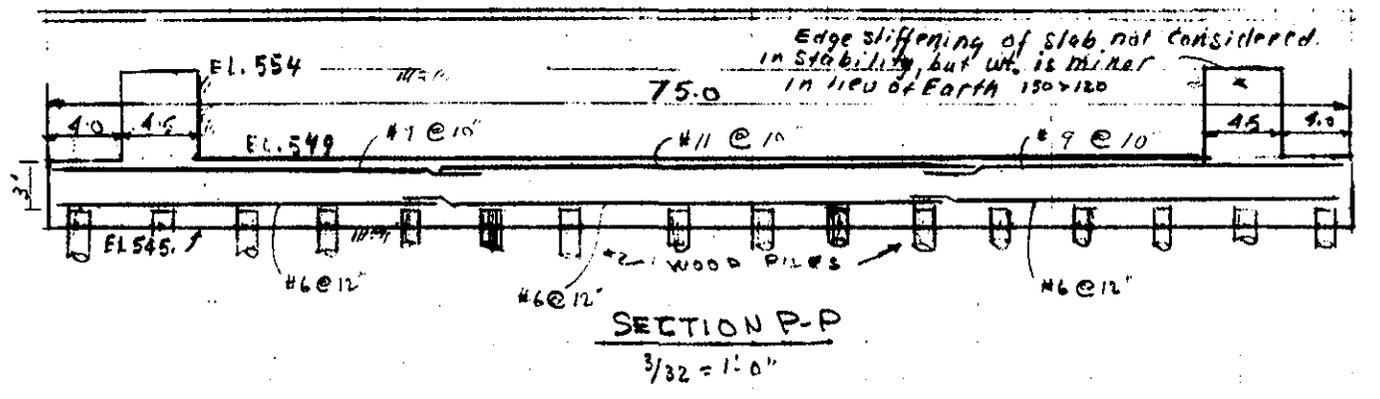
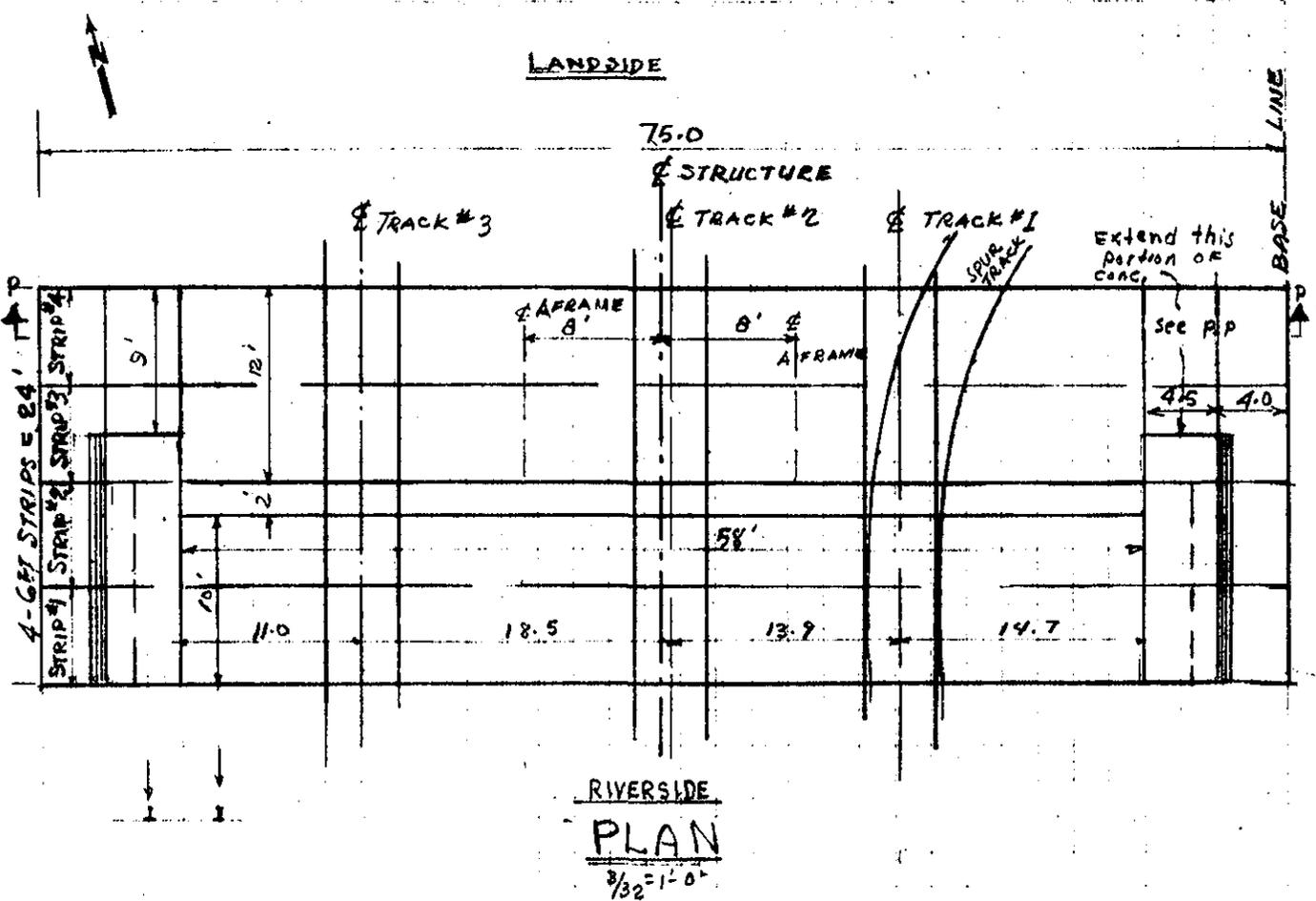
CASE II	
PILE #	18'
①	$\frac{873.3 \cdot 3.9}{48} + \frac{1633 (9.23)}{3817.6} = +21.9'k$
⑥	$18 - 2.9 = +14.1'$
⑦	$-3.9'k$ TENSION
⑫	$+3.9'k$ COMPRESSION

SUBJECT ST. JOHNSBURY, VT.
COMPUTATION RAILROAD GATE

COMPUTED BY Ejm

CHECKED BY

DATE OCT 1966

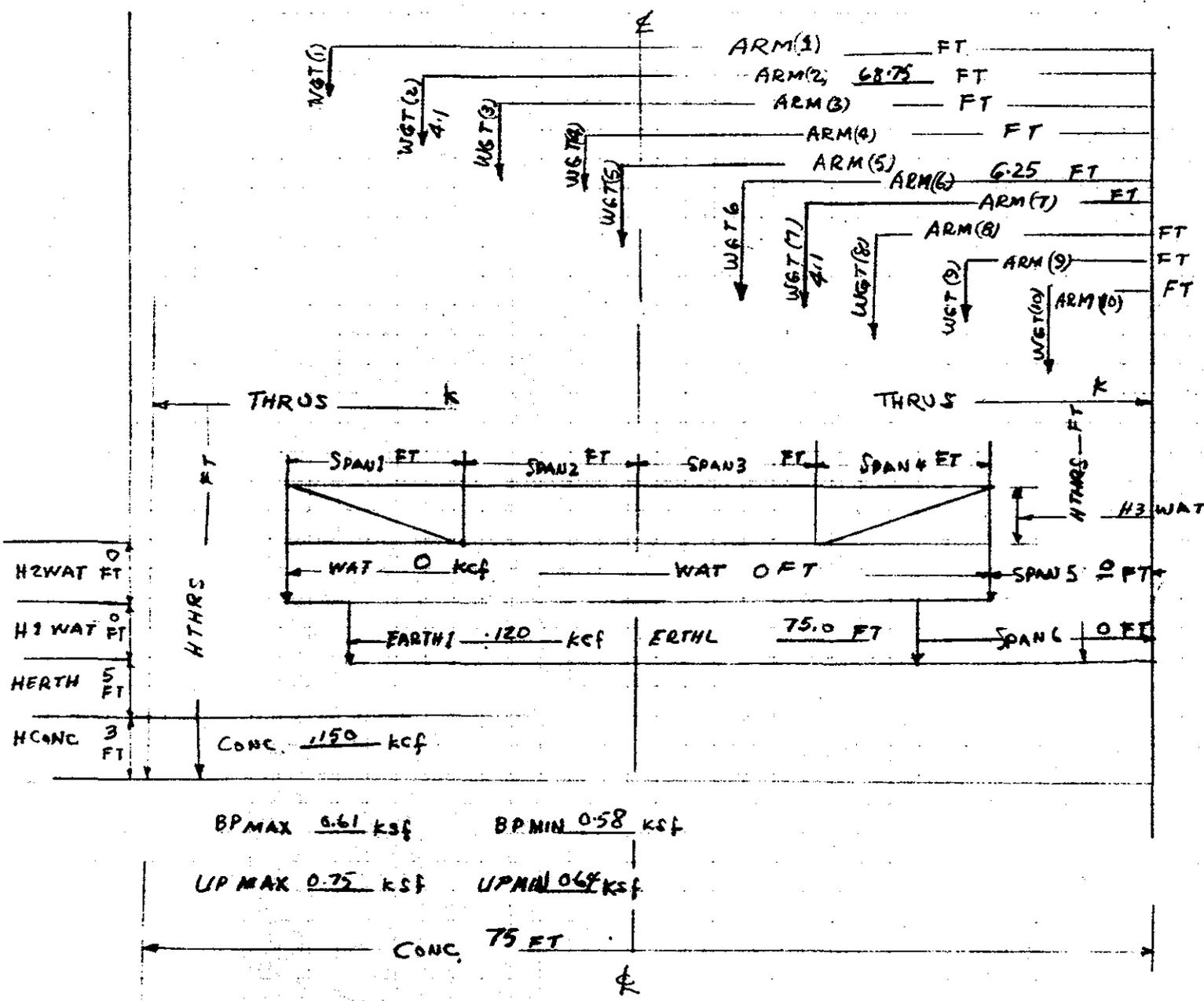


SUBJECT ST. JOHNSBURY, VT.
COMPUTATION RAILROAD GATE

COMPUTED BY Expn CHECKED BY _____
CASE D - Strip No. 4 WATER LOADING
DATA FOR COMPUTER PROCESS

DATE Nov. 1966

(6 FT WIDE)



SUBJECT ST. JOHNSBURY, VT.

COMPUTATION RAILROAD GATE

COMPUTED BY _____

CHECKED BY _____

DATE Nov. 1966

NAME OF PROJECT ST. JOHNSBURY VT. 31 OCT 66

RAILROAD GATE STRIP NO.4 6FT WIDE

WATER LOADING

0.00	4100.00	0.00	0.00	0.00		
0.00	4100.00	0.00	0.00	0.00		
0.00	0.00					
0.00	68.75	0.00	0.00	0.00		
0.00	6.25	0.00	0.00	0.00		
0.00	0.00					
0.00	120.00	150.00	6.00	75.00	0.00	75.00
5.00	0.00	3.00	0.00	0.00	0.00	0.00
610.00	580.00	750.00	640.00	0.00	0.00	0.00
0.00	0.00	0.00	120000.00	3000.00	152.00	1450.00

SECT. FT	SHEAR LB	MOMENT FT LB	SBP PLF	CREQ IN	DGIV IN	V PSI	REINF
75.00	0.	0.	-4351.	0.00	32.50	0.00	0.00
71.25	-7609.	-14267.	-4164.	3.96	31.50	-3.35	-0.05
67.50	36241.	7695.	-3975.	2.90	32.50	15.49	0.03
63.75	30032.	131957.	-3787.	12.03	32.50	12.83	0.47
60.00	24490.	234188.	-3609.	16.02	32.50	10.47	0.83
56.25	19553.	316769.	-3446.	18.64	32.50	8.36	1.12
52.50	15139.	381817.	-3305.	20.46	32.50	6.47	1.35
48.75	11151.	431111.	-3191.	21.74	32.50	4.77	1.52
45.00	7477.	466038.	-3106.	22.61	32.50	3.20	1.65
41.25	3997.	487551.	-3054.	23.12	32.50	1.71	1.72
37.50	585.	496142.	-3036.	23.32	32.50	0.25	1.75
33.75	-2887.	491825.	-3052.	23.22	32.50	-1.23	1.74
30.00	-6546.	474137.	-3102.	22.80	32.50	-2.80	1.68
26.25	-10514.	442150.	-3185.	22.02	32.50	-4.49	1.56
22.50	-14904.	394492.	-3298.	20.80	32.50	-6.37	1.40
18.75	-19817.	329389.	-3439.	19.00	32.50	-8.47	1.16
15.00	-25338.	244723.	-3602.	16.38	32.50	-10.83	0.87
11.25	-31529.	138097.	-3782.	12.31	32.50	-13.47	0.49
7.50	-38425.	6934.	-3972.	2.76	32.50	-16.42	0.02
3.75	8307.	-15576.	-4162.	4.13	31.50	3.66	-0.06
-0.00	0.	1.	-4351.	0.03	32.50	0.00	0.00

UNBALANCED LD. RIGHT, 50236.

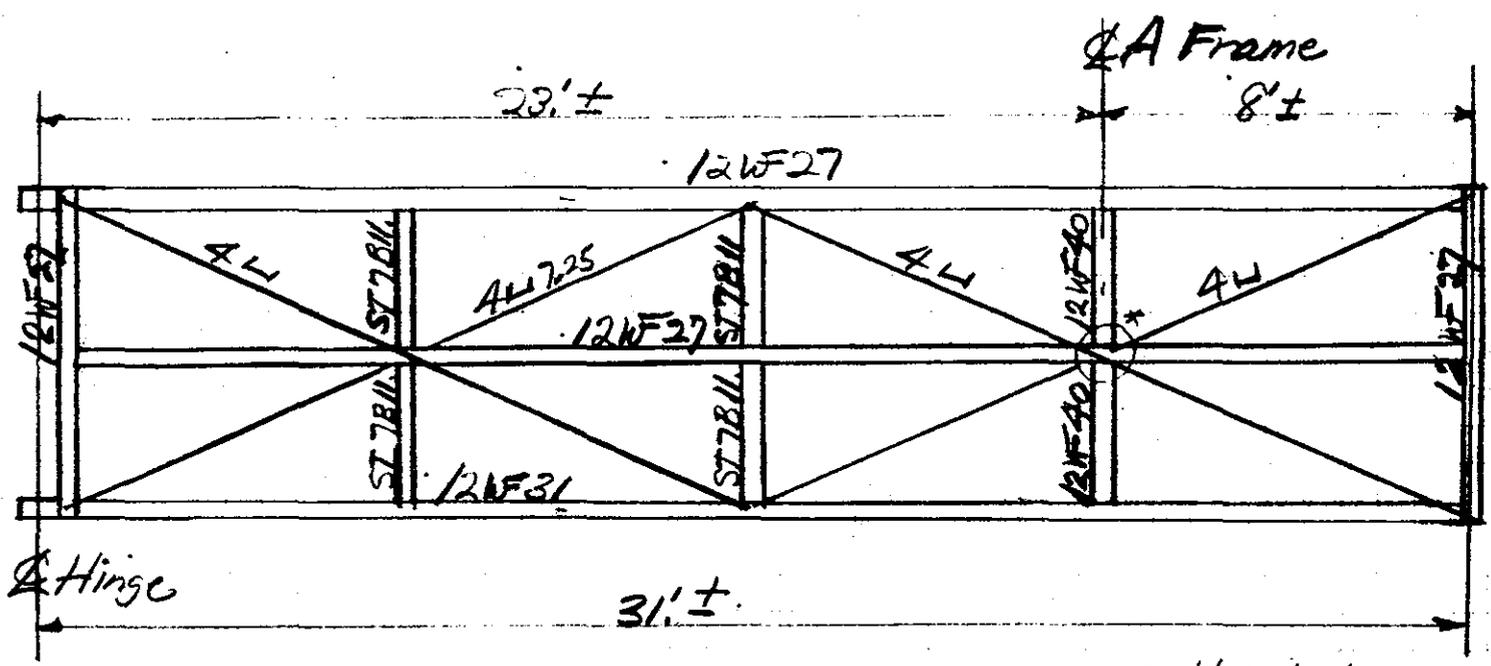
UNBALANCED LD. LEFT, 46657.

END-OF-DATA ENCOUNTERED ON SYSTEM INPUT FILE.

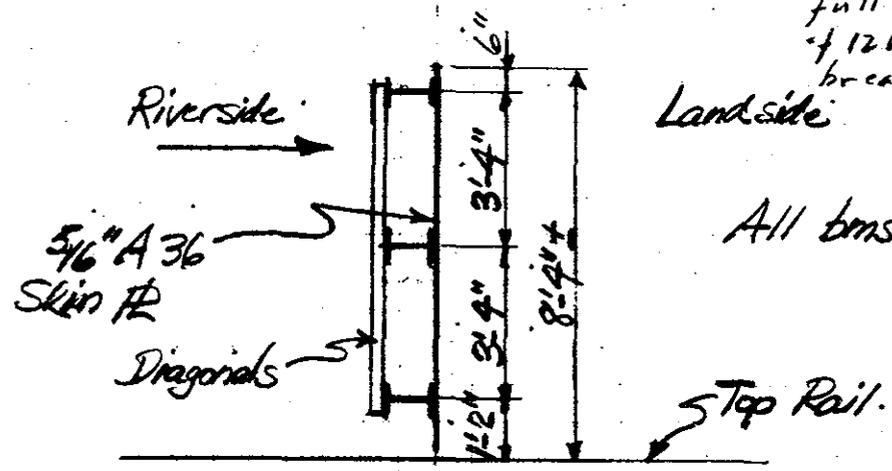
SIGN DESIGNATION:

MOMENT + -
 SHEAR + -
 RESTEEL + TOP, - BOT

SUBJECT St. Johnsburg Railroad Gate
 COMPUTATION BY G.R.
 ORDERED BY C.C.C.
 DATE June 1946



* Weld to develop full strength of 12WF40's across break.



All brns. = A36.

SUBJECT St. Johnsbury Vt.

COMPUTATION Railroad Gate

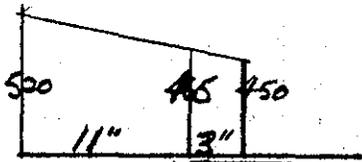
COMPUTED BY GR.

CHECKED BY CCC.

DATE June 1966

SKIN PL

	G1		G2		G3	
	520	450	240			
	0	10	.5	.5	10	
	12"		3'-4"		3'-4"	6"
FEM	325	340	300	145	106	0
			8	53		
			308	198		
			45	55		
	325	325	253	253	0	0
- M						
+ M			220	100		
Vs =	570	633	517	285	170	5
ΔM/L =		22	-17	+75	-65	
V =	570	655	500	360	105	5
Bm Id. =	1230.		860		110	



$465 \times 1.0 \times .5 = 230$
 $55 \times .5 \times 6 = 15$
 $- M = 245.$

At upper flg. G1

$- 225$
 $+ \frac{1}{3} \times 655 \times .5 = +105$
 $- M = 220.$

$5/16" \text{ PL} - S = 0.20'$

$f_b = \frac{12 \times 245}{20} = \pm 14.7 \frac{1}{2}''$

A36 Allow = 18.0 k

Use $5/16"$ A36 Skin PL

27 Sept 49

SUBJECT St. Johnsbury Vt.

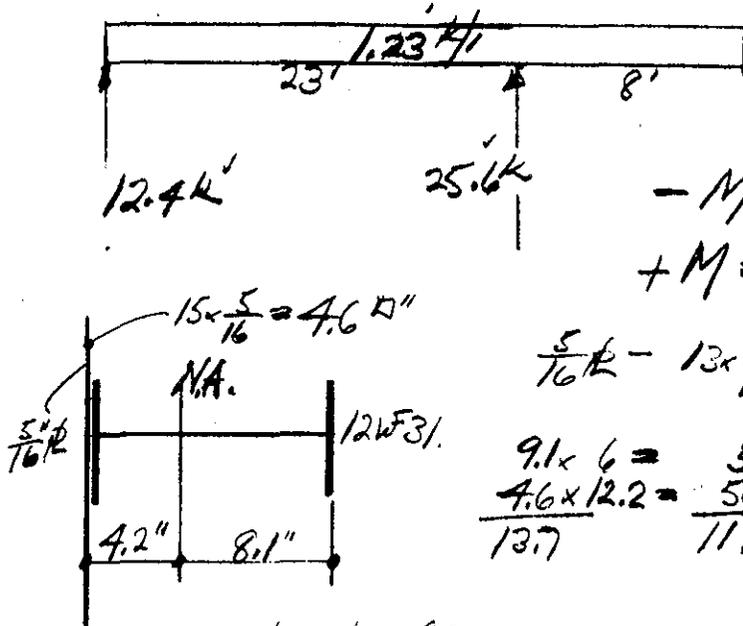
COMPUTATION Railroad Gate

COMPUTED BY G.R.

CHECKED BY G.R.

DATE June 1966

Girder G1



$$31 \times 1.23 = 38.1 \text{ k}$$

$$\frac{38 \times 15.5}{23} = 25.6 \text{ k}$$

$$-M = 1.23 \times 8 \times 4 = 40.1 \text{ k}$$

$$+M = 12.4 (10 - 5) = 62.1 \text{ k}$$

$$\frac{5}{16} \text{ k} - 13 \times \frac{5}{16} = 4.1 \text{ k} \rightarrow 4 + 4 + 0.1 = \text{Say } 8.1 \text{ k}$$

$$\frac{9.1 \times 6 = 55}{4.6 \times 12.2 = 56} = \frac{55}{56} = 0.982$$

$$\frac{11.1}{13.7} = 8.1 \text{ k}$$

$$4.6 \times 4.7^2 = 77$$

$$9.1 \times 2.7^2 = 40$$

$$238$$

$$I = 355$$

$$f_b = \frac{12 \times 62 \times 8.1}{355} = +8.8 \text{ k/in}^2 < 18.0 \text{ ok}$$

$$-17.0$$

$$L_b \leq 13 \times 6.5 = 84.5 \text{ max.}$$

Use 12WF31-A36 for G1

Shear pl combined stress

$$f_b = \pm 14.7 \text{ (1)}$$

$$f = +8.8 \text{ (above)}$$

$$\text{Max. shear} = \frac{14.7 + 8.8}{2} = 11.8 \text{ k/in}^2$$

$$\text{Allow} = .33 \times 36 = 12.0 \text{ ok}$$

SUBJECT ST. JOHNSBURY, VT.

COMPUTATION RAILROAD GATE

COMPUTED BY EJM

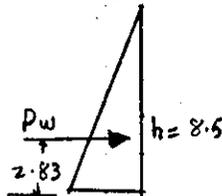
CHECKED BY C. C. C.

DATE JUNE 1966

"A" FRAME

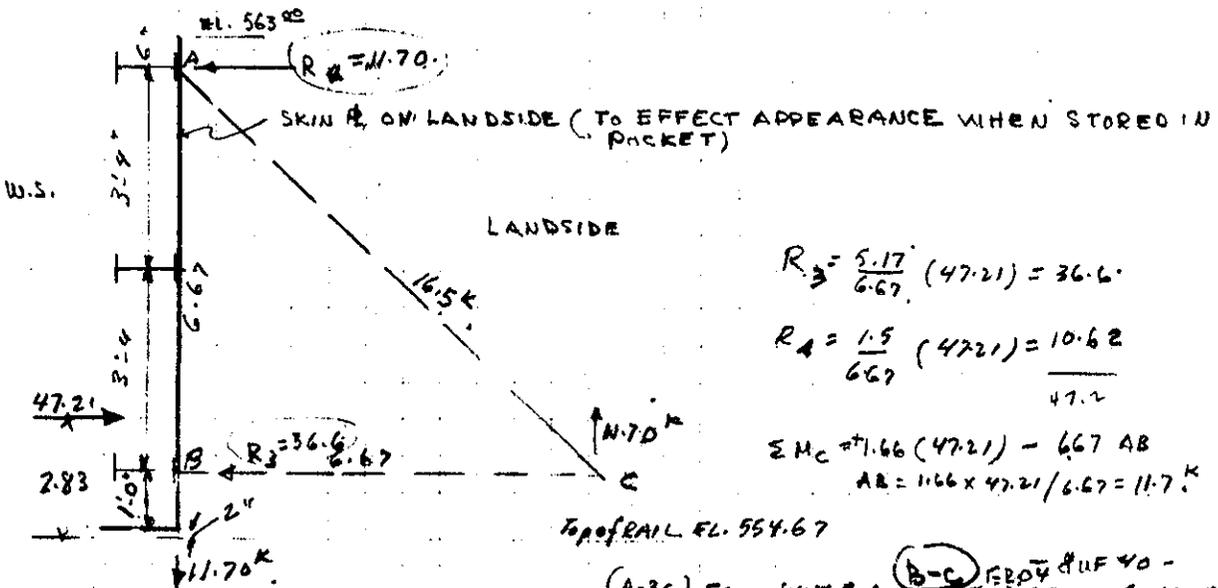
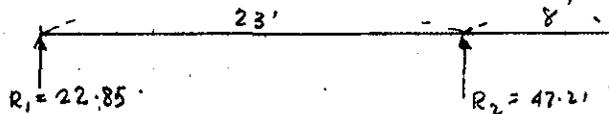
REACTION @ AREA OF A-FRAME DUE TO HYDROSTATIC PRESSURE -
WATER ELEVATION 563.00 (TOP OF GATE)

USE $h = 8.5$ (FOR HYDROSTATIC HEIGHT)



$$P_w = \frac{8.5^2}{2} (0.0625) = 2.26^k$$

LENGTH OF GATE SECTION ASSUMED 31' ∴ $31 \times 2.26^k = 70.06^k$ TOTAL @ GATE SECTION



$$R_3 = \frac{5.17}{6.67} (47.21) = 36.6$$

$$R_A = \frac{1.5}{6.67} (47.21) = 10.62$$

$$\Sigma M_C = +1.66 (47.21) - 6.67 AB$$

$$AB = 1.66 \times 47.21 / 6.67 = 11.7^k$$

B-C $P = 36.6$

(A-C) Try $f_w = 20$ $f_c = 3.53$ $A = 11.76$ $S = 35.5$ $F_A = 19.2$

$$\frac{KL}{r} = \frac{1(6.67)(12)}{204} = 39.3$$

$$f_c = 36.6 / 11.76 = 3.12$$

$$\frac{f_a}{F_A} = \frac{3.12}{19.2} = 0.165$$

(A-C) Try $f_w = 20$ $f_c = 1.20$ $A = 5.88$

$$P = 16.5$$

$$\frac{KL}{r} = \frac{1(9.42)(12)}{1120} = 94.2$$

$$F_A = 13.70$$

$$f_a = 16.5 / 5.88 = 2.81$$

$$\frac{f_c}{F_A} = \frac{2.81}{13.70} = 0.205$$

SUBJECT ST. JOHNSBURY PUMPING STATION

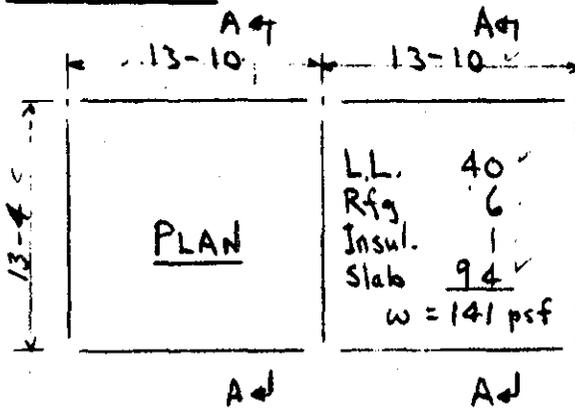
COMPUTATION

COMPUTED BY C.C.C.

CHECKED BY [Signature]

DATE OCT. 1966

ROOF SLAB



Allow. $f_c/f_s = 1350/20,000$ psi $f'_c = 3000$ psi

Allow. $v = 60$ psi $K = 226$

$j = .872$ $a = 1.44$

ACI Method II: $S = 13.3'$ $m = 13.3/13.8 = .96$

Case 4: 3 edges discontin. :

	C	
	Short Span	Long Span
- M @ Contin. Edge	-	.058
- M @ Discontin. Edge	.031	.029
+ M @ Mid-Span	.046	.044

Max. -M = $CwS^2 = .058 \times 141 (13.3)^2 = 1.45$ k'/1

Req'd. -d = $\sqrt{1.45/226} = 2.5$ " Actual min. d = $6 - 3/4 - v_d = 5.0$ " O.K.

Req'd. -A_s = $1.45 / (1.44 \times 5.0) = 0.20$ sq'/1

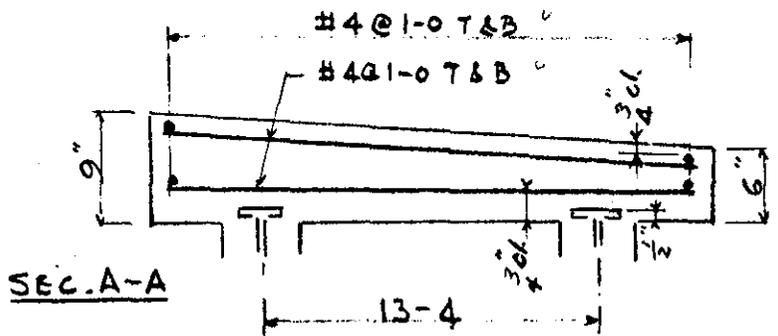
Min. T & S Reinf. = $.0012 \times 12 \times 7.5 = 0.11$ sq'/1

Use #4 @ 1-0, EW, EF

Max V < $141 \times 13.8 / L < 973$ #/1

Max v < $973 / (12 \times 5.0) < 16$ psi O.K.

Max u < $973 / (1.6 \times .872 \times 5.0) < 139$ psi. Allow 500. O.K.



SUBJECT ST. JOHNSBURY PUMPING STATION

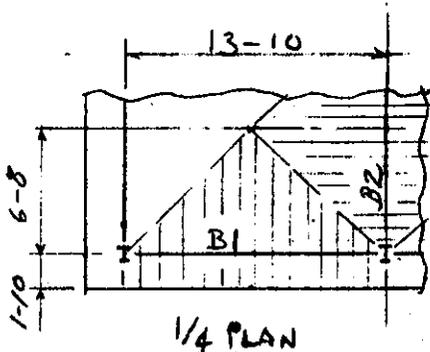
COMPUTATION

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CHECKED BY [Signature]

DATE OCT. 1966

ROOF FRAMING = B1 A36: $f_s = 22 \text{ K/in}^2$



B1 load area = $13.83' (6.67'/2 + 1.83') = 71.4 \text{ ft}^2$

$w = 40 + 6 + 1 + av. 103 = 150 \text{ psf}$

$$\begin{aligned} W &= 71.4 \text{ ft}^2 \times 150 \text{ psf} = 10,700 \text{ lbs} \\ &= 13.8' \times 20' = 280 \text{ lbs} \\ \text{Encase} &= 13.8' \times .83' \times .87' \times 150 \text{ psf} = 1,500 \text{ lbs} \\ \hline 12,480 \text{ lbs} &= W \\ 6,240 \text{ lbs} &= R \end{aligned}$$

$M = 12.48 \text{ K} \times 13.8' / 8 = 21.5 \text{ K}'$

AISC Chart, p. 2-53: $3 \text{ WF } 17 \times 14' = \text{Allow } 17 \text{ K}' \text{ N.G.}$
 $20 \quad 25 \quad \text{O.K.}$

Defl. = p. 2-29, $= (12.48 \text{ K} \times .61'' / 19.4 \text{ K}) / 166'' = 1/423 \text{ span O.K.}$

Use 8 WF 20 for all 6 Spandrels, Fr. Brn. Ganss, 3/4 HS Bolts

B2 = (1 req'd. Not encased) (middle suppt of 2 spans)

$$\begin{aligned} 4 \times \frac{6.83' \times 6.67'}{2} &= 91.1 \text{ ft}^2 \times 1.25 \times 141 \text{ ft}^2 = 16,000 \text{ lbs} \\ \text{WF} &= \frac{16,400 \text{ lbs}}{400} = W \\ &= \frac{8,200 \text{ lbs}}{100} = R \end{aligned}$$

$M = 16.4 \text{ K} \times 13.3' / 8 = 27.3 \text{ K}'$

AISC p. 2-53: $8 \text{ WF } 20 \text{ Allow } 25 \text{ K}' \text{ N.G.}$
 $10 \text{ WF } 21 \text{ } 25.5 \text{ N.G.}$
 $10 \text{ B } 27.9 \text{ } 32 \text{ O.K.}$
 $8 \text{ WF } 24 \text{ } 38.5 \text{ O.K.}$

$8 \text{ WF } 24 \text{ Defl. p. 2-29, } = (16.4 \text{ K} \times .61'' / 23.8 \text{ K}) / 160'' = 1/380 \text{ SPAN O.K.}$

Use 8 WF 24

SUBJECT ST. JOHNSBURY PUMPING STATION

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CRANE BEAM = Contin. over 2 spans @ 13'-10"

Crane capacity	4000 [#]	$\times .20 \times \frac{1}{2} =$	400 [#]
Bridge, single girder	$1200# \times \frac{1}{2} =$	600	
Hoist; low head r.m.s. chain	450	$\times .20 \times \frac{1}{2} =$	45 [#]
	5050		
25% impact	1250 [#]		
	6300 [#]		

Vert. P < 6300[#]

AISC p 2-130 #31

$$M_a = \frac{Pa(1-a)}{4l^3} [4l^2 - a(p+a)]$$

For max = $\frac{dM_a}{da} = 0 = \frac{P}{4l^3} [4l^2 - 10al^2 + 4a^3]$

$$a^3 - 2.5al^2 + l^3 = 0 \quad a = .4323l$$

$$M_a = \frac{6300(4323 \times 13.83)(13.83 - 4323 \times 13.83)}{4(13.83)^3} [4(13.83)^2 - 4323 \times 13.83(13.83 + 4323 \times 13.83)]$$

$$= 18,030^{\#'} \quad \left[\text{vs. } 13Pl/64 = 13 \times 6300 \times 13.83 / 64 = 17,700^{\#'} \text{ for } P @ \text{ c span} \right]$$

$$M_a = \frac{580}{128} = 960^{\#'} / 128 = 9 \times 43(13.83)^2 / 128$$

Approx. for beam & rail.

Horiz. $M_a = \frac{445}{6300} (18610) = 1320^{\#'}$



Try 10W 33 = Horiz S = $.433(7.964)^2 / 6 = 4.58¹¹$

Vert f = $18,610 \times 12 / 35.0 = 6380 \text{ psi}$ } O.K. for $L_u = 16.1$ vs. actual 13.83'

Horiz f = $1320 \times 12 / 4.58 = 3460 \text{ psi}$ } Allow R = 35 k

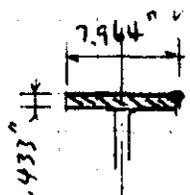
Δ max approx $.015 Pl^2/EI = \frac{.015 \times 6300 (13.83 \times 12)^3}{29,000,000 \times 170.9} = .089''$ O.K.

AISC p 2-130, #30

Use 10W 33, continuous over 2 spans - Same fastenings as Stanch. Wamp. sheet 61.

Max. bracket reaction = $6300 + 13.83(33 + 10) = 6300 + 550 = 6850^{\#}$

Use 7,200^{\#}



SUBJECT

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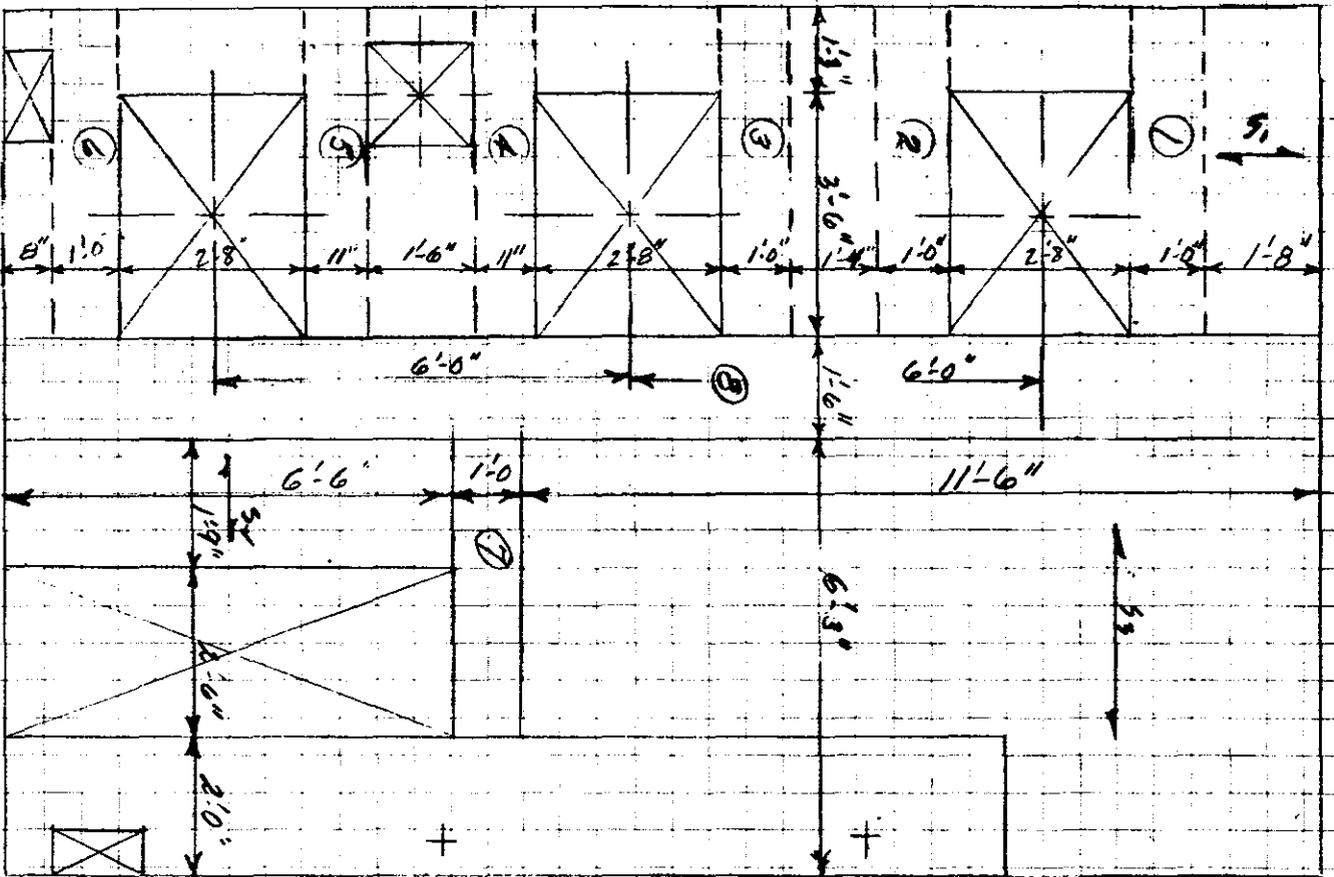
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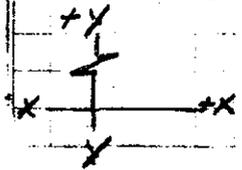
E. R. G.
OCT 1966

Electrical Equipment Area



PLAN - OPERATING FLOOR
Scale 3/8" = 1'-0"

Operating Floor Plan (Area over Sump)
Scale 3/8" = 1'-0"



SUBJECT

St. JOHNSBURY

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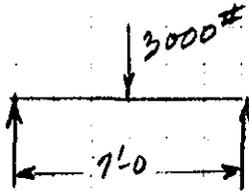
DATE

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Operating Floor

Determination of Live Load

The maximum wt. of a single piece of equipment will be the pump. wt 3000#/unit. Assume this is placed in the center of the 7'-0" span and check for equivalent live load. Dist over 1'-0" of WIDTH. $\frac{3000}{4} = 750\#$



$$M = 1/4 \times 750 \times 7.0 = 1310 \text{ ft}\cdot\#$$

$$1/8 \text{ WL}^2 = 1310$$

$$W = \frac{1310 \times 8}{7.0 \times 7.0} = 214 \text{ \#/ft}$$

say 225 \#/ft. ✓

Slab 5-1

C.C. Span = 2'-11" or 2.92' $t = 6"$

L.L. = 225

D.L. = $\frac{75}{300} = 300 \text{ \#/ft.}$

+ M. $1/8 \times 300 \times 2.9^2 = 320 \text{ ft}\cdot\#$

As = $\frac{320 \times .6}{.87 \times 5} = .05 \text{ sq ft.}$

1/2 min. As. # 5 @ 12" Top & Bot.

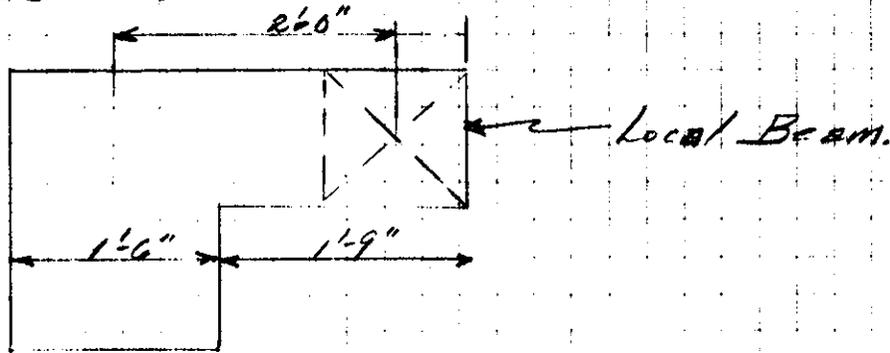
U = $\frac{300 \times 2.9 \times 1/2}{1.9 \times .87 \times 5} = 53 \text{ psi}$

w = $\frac{300 \times 2.9 \times 1/2}{12 \times 6} = 60 \text{ psi}$

SUBJECT St. JOHNSBURY
COMPUTATION PUMPING STATION
COMPUTED BY E.P.G. CHECKED BY Wym DATE OCT. 1966

Operating Floor Cont.

Slab 5-2



1. Try as slab spanning between B-8 & Local beam next to floor opening.

$$L.L. = 225$$

$$D.L. = \frac{150}{375 \#/ft}$$

$$W = \frac{1}{8} WL^2 = \frac{1}{8} \times 375 \times 2.0^2 = 175 \# \text{ Use min. As.}$$

Check as cantilever.

$$M = \frac{1.75 \times 375}{2} = 575 \#'$$

$$As = \frac{575 \times 6}{.87 \times 7.5} = .05 \text{ si/ft. Use min. As. } \underline{OK}$$

Slab 5-3

Note: make Slab 5-4 equipment room similar to 5-3 Clear Span = 6'-0"

$$C.C. \text{ SPAN} = 6.25' + 1.5' = 7.75' \quad L.L. = 225$$

$$M = \frac{1}{8} WL^2 = \frac{1}{8} \times 300 \times 7.75^2 = 2.25 \text{ k/ft.} \quad D.L. = \frac{25}{300 \#/ft}$$

$$\text{reqd. } d = \sqrt{\frac{2250}{226}} = 3.2" \text{ ok.}$$

$$As = \frac{2.25 \times 6}{.87 \times 4.5} = .34 \text{ si/ft. use } \# 5 @ 10"$$

$$W = \frac{300 \times 7.75^2}{2} = 1.15 \text{ k} \quad W = \frac{1.15}{12 \times 6} = 16.0 \text{ psi ok.}$$

$$W = \frac{1.15}{2.4 \times 4.5} = 14.0 \text{ psi } \underline{OK}$$

SUBJECT ST. JOHNS BURY

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Operating Floor Cont.

Beam 1.

- a. Use c. c. for spans.
- b. Say beam are loaded from end to end.

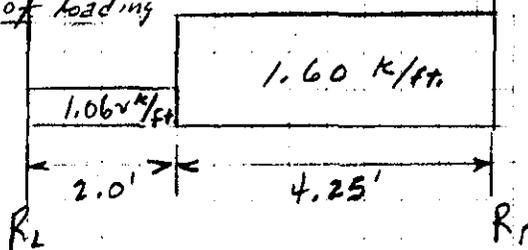
D.L. Bm. 12/15 = .187 k/ft.
L.L. = .225 k/ft.
D.L. slab = .075 k/ft.

Pump = 3000 #
Motor = 2000
Thrust = 3000
8000 #
4000 #
4.25 = .940 #/ft

loading

slab. D.L. + L.L. $\times 10/12 = .250$	
.075 + .225 = .300	
Bm. D.L. + L.L. = .412	
slab. L.L. + D.L. $\times 1.33 =$	PUMP
.225 + .075	loading

End loading



1.60
1.062
0.58

$K = \frac{224}{236}$

(see sh. 27 for print out)

Other Beams

Beam 2-6 Use same loading as for beam #1
The loading for beam #1 is slightly larger than the loading for the other beams.

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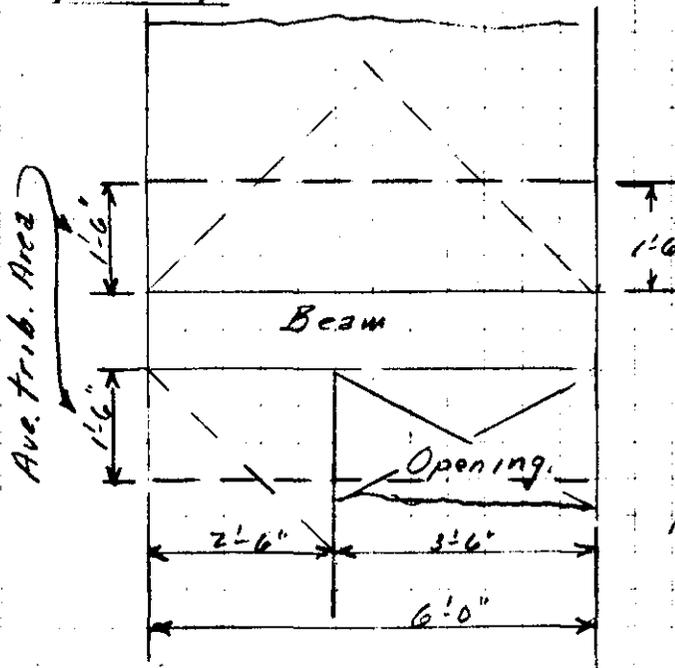
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Operating Floor Cont.

Beam ①.

Span = 1'-9" + 2'-6" + 9" + 1'-0" = 6'-0" C.C.

Loading



Slab D.L. = .075

" L.L. = .225

Bm. 1200 D.L. = .150

Bm L.L. = .225

Note In lieu of actual loading indices of opening, use slab D.L. .075 & L.L. .225 w/st for simplicity.

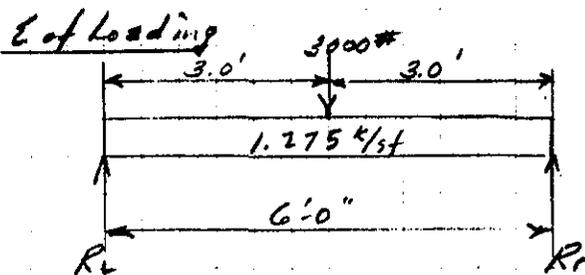
∴ Beam will have following loads.

$(.300 \times 1.5 \times 2.0) + (.150 + .225) = 1.275 \text{ k/ft}$
PLUS 3000# (PUMP) @ $\frac{1}{2}$

$R_L = R_R = 1.275 \times 3.0 + 1500 = 5.3 \text{ kips}$

$v = \frac{5.3}{12 \times 15} = 30 \text{ psi}$

$n = \frac{53}{1.9 \times 89 \times 12} = 2600 \text{ k}$



$M = \frac{1}{8} w l^2 + \frac{P l}{4} = 5.7 + 4.6 = 10.3 \text{ 'k}$

$A_s = \frac{10.3 \times 12}{.89 \times 12} = .6 \text{ 'si} \quad 2\#5 \text{ T. \& Bot.}$

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COMPUTATION PUMPING STATION

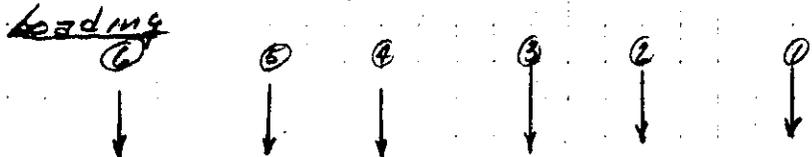
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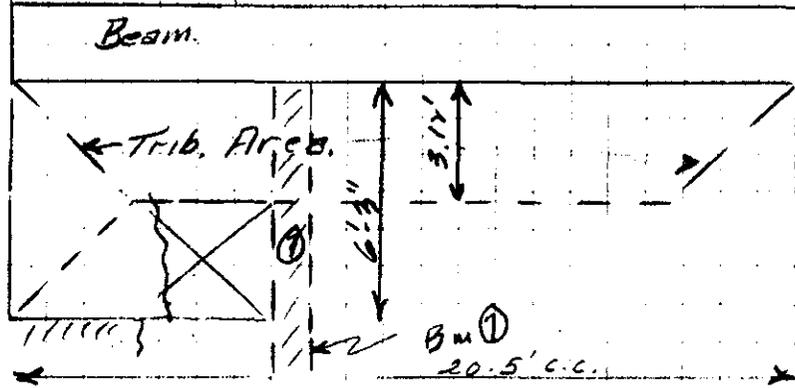
DATE OCT. 1966

Operating Floor

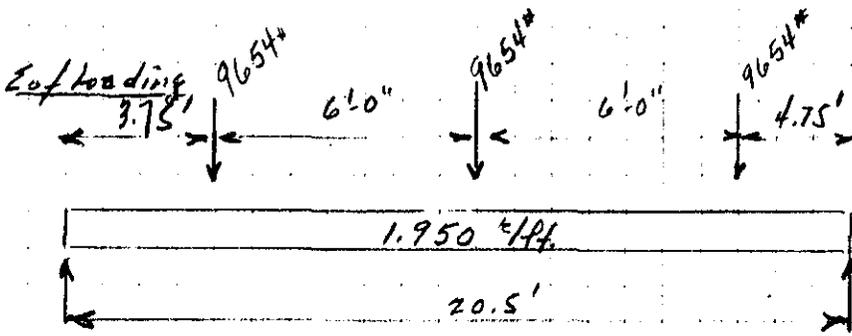
Beam 8. Span 19'-0" clear 20.5' c.c.



Bm. DL, 18x36 = .675
 Bm L.L., 1.5x275 = .340
 Slab. DL, 3.17x.075 = .235
 L.L., 3.17x275 = .700



omit Bm. 7 for simplicity.



From Ref. Conc.
 Design Hbk
 SP-3 pg. 94
 $t/d = 6/30 = .20$

$k = 182$

for $f_c' = 3000$
 $n = 9.2$
 $f_s = 20,000$
 $f_c = 1350$

SUBJECT ST JOHNSBURY
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BEAM NO. 1

ENTER FOLLOWING ITEMS:-----

SPAN IN FEET = 6.25 BEAM WIDTH B = 12
BEAM HEIGHT B = 15 TEE BM. WIDTH B' = 12
LL PLUS DL = 1062 K = 236
LL #1 = DIST TO LL = LENGTH OF LL =
LL #2 = 538 DIST TO LL = 2.0 LENGTH OF LL = 4.25
CONC.LD.#1= DIST TO LOAD =
CONC.LD.#2= DIST TO LOAD =
CONC.LD.#3= DIST TO LOAD =

ANSWERS

L REACT= 4096.16 R REACT= 4827.84
UNIT V L = 22.75 UNIT V R= 26.82
X0= 3.85
M= 15798.98 REQ'D= 8.18
AS = .87

END

BEAM NO. 8

ENTER FOLLOWING ITEMS:-----

SPAN IN FEET = 20.5 BEAM WIDTH B = 18
BEAM HEIGHT B = 30 TEE BM. WIDTH B' = 39
LL PLUS DL = 1950 K = 182
LL #1 = DIST TO LL = LENGTH OF LL =
LL #2 = DIST TO LL = LENGTH OF LL =
CONC.LD.#1= 9654 DIST TO LOAD = 3.75
CONC.LD.#2= 9654 DIST TO LOAD = 9.75
CONC.LD.#3= 9654 DIST TO LOAD = 15.75

ANSWERS

L REACT= 35174.89 R REACT= 33762.10
UNIT V L = 65.13 UNIT V R= 62.52
X0= 8.13
M= 286213.39 REQ'D= 21.99
AS = 7.22

END

27 Sept 49

SUBJECT

ST. JOHNSBURY

COMPUTATION

PUMPING STATION

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E. P. G

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DATE

OCT 1966

Summary of Loading Conditions

Case I

Concrete & Earth

Sump Empty

Lateral Loads equal & Opposite - Omit

Case II

Case I

Water in Bypass & Intake to Elev. 542.00

Uplift from El. 537. to El. 550. over full base.

Case III

Case I

Water in Bypass, Intake & Sump to El. 541.50

Uplift from El. 537. to El. 550. over full base.

Case IV

Case I

Water in Bypass, Intake & Sump to El. 546.00

Uplift from El. 537. to El. 550. over full base.

SUBJECT ST. JOHNSBURY

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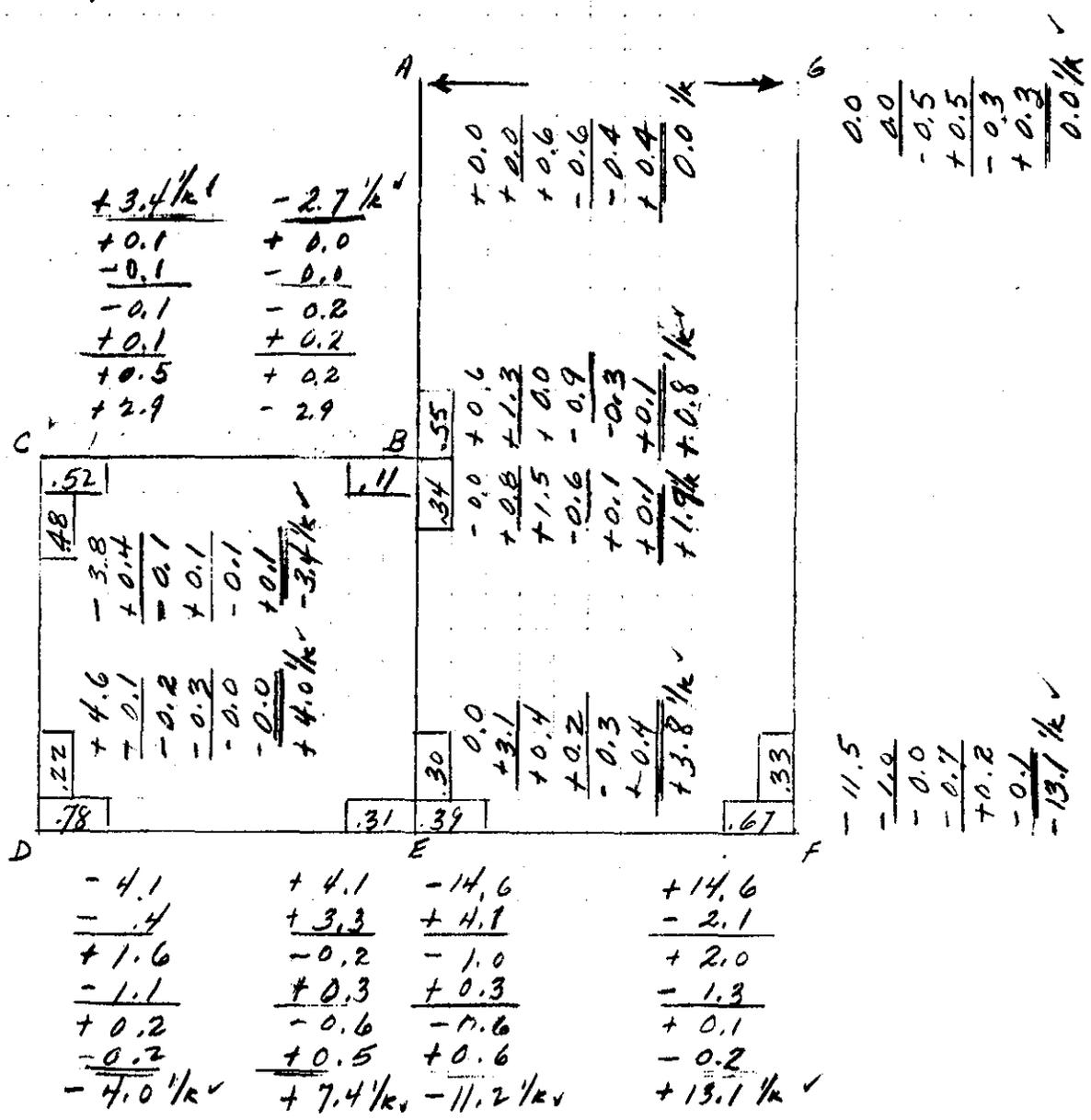
DATE OCT 1966

*Case I
Concrete & Earth.*

ITEM	FACTORS	WT*	Y Arm*	X Arm*	M x-1/2	M y-1/2
1	Roof Slab 17.3x31.3x.62x.150	50.4	14.75	14.75	743.-	743.-
2	Spandrel No. 1.0x1.0x14.3x.150	2.1	14.75	1.00	31.-	2.-
3	" E. 1.0x1.0x29.3x.150	4.4	21.50	14.75	95.-	65.-
4	" So. 1.0x1.0x14.3x.150	2.1	14.75	28.50	31.-	60.-
5	" W. 1.0x1.0x29.3x.150	4.4	8.00	14.75	35.-	65.-
6	Roof Bm. E 13.3x.033	.4	14.75	14.75	6.-	6.-
7	Brick Wall No. 13.3x1.0x13.0x.170	20.7	14.75	.50	305.-	11.-
8	" E. 29.3x1.0x13.0x.170	45.7	21.75	14.75	994.-	674.-
9	" So. 13.3x1.0x13.0x.170	20.7	14.75	29.00	305.-	600.-
10	" W. 29.3x1.0x13.0x.170	45.7	7.50	14.75	343.-	674.-
11	Op Fl. Slab & Bwl-6 4.75x19.0x.5x.150	6.8	18.63	14.75	127.-	100.-
12	" " Bm 8 1.5x2.5x19.0x.150	10.7	15.50	14.75	166.-	158.-
13	" " Slab & Bwl-7 6.25x19.0x.5x.150	8.4	11.62	14.75	103.-	131.-
14	Sump WALL No. 12.5x1.5x11.0x.150	30.9	14.75	.75	456.-	23.-
15	" " E. 29.5x1.5x11.0x.150	73.0	21.75	14.75	1590.-	1075.-
16	" " So. 12.5x1.5x11.0x.150	30.9	14.75	28.75	456.-	290.-
17	" " W. 29.5x1.5x11.0x.150	73.0	7.75	14.75	566.-	1077.-
	- OMIT					
17	Int Sump Wall 12.5x11.0x1.5x.150	30.9	14.75	21.25	456.-	657.-
20	Base SLAB 29.5x15.5x2.0x.150	137.2	14.75	14.75	2024.-	2024.-
21	Intake Roof 7.0x29.5x1.0x.150	31.0	3.50	14.75	109.-	457.-
22	" No 6.0x1.0x6.0x.150	5.4	4.00	.50	22.-	3.-
23	" West 29.5x1.0x6.0x.150	26.6	.50	14.75	13.-	392.-
24	" So 6.0x1.0x6.0x.150	5.4	4.00	29.00	22.-	157.-
25	" Base Slab 7.0x29.5x1.5x.150	46.5	3.50	14.75	163.-	686.-
26	Door 5.0x7.0x1.0x.170	4.2	7.50	10.50	32.-	44.-
27	Gate Opening 4.5x4.5x1.5x.150x2.0	9.1	7.75	11.00	71.-	100.-
28	Pipe Inlet .785 5.5x1.5x.150	-	14.75	25.00	-	-
29	" Outlet " " "	-	7.75	25.00	-	-
30	Wall "out" 6.0x1.5x8.0x.150	10.8	7.75	25.00	84.-	270.-
31	Crane Rails 27.3x.033 x 2.	2.0	14.75	14.75	30.-	30.-
32	" 2.0 Est.	2.0	14.75	14.75	30.-	30.-
33	Gates 2x5.0	10.-	7.75	11.00	78.-	110.-
34	Pumps 3x5.0	15.-	11.00	10.50	165.-	158.-
35	Earth 29.5x7.0x4.0x.130	107.4	3.50	14.75	376.-	1584.-
36	Window 5.5x5x1.0x.170	3.3	7.50	10.5	25.-	35.-
		812.15			9507.44	11925.14

$$\frac{EM_{44}}{EV} = \frac{11925}{812.1} = 14.68' \quad \& \quad \frac{EM_{9507}}{EV} = \frac{9507}{812.1} = 11.71'$$

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Dist Factors

Joint B		c	d	e	f
5.7	5.7/10.3 = .55	1.0	1.0 = .22	3.5	3.5 = .31
1.1	1.1/10.3 = .11	2.1	4.5	3.3	11.1 = .67
3.5	3.5/10.3 = .34	4.1	3.5 = .78	4.3	3.3 = .30
10.3		2.1	4.5	11.1	4.3/11.1 = .39
					2.1/6.4 = .37

27 Sept 49

CORPS OF ENGINEERS, U. S. ARMY

SUBJECT ST JOHNSBURY

COMPUTATION PUMPING STATION

COMPUTED BY F.P.G.

CHECKED BY G.M.

DATE Oct. 1966

Case III Concrete, Uplift from Elev. 550.-
Water in Bypass, Sump & Intake to E 541.5

ITEM	WT.	Y Arm	X Arm	M _{x-x}	M _{y-y}
Forward	812.1			9507.-	11925.-
Water Bypass 6.0x12.5x3.0x.063	14.2	14.75	25.00	209.-	355.-
" Intake 27.5x6.0x3.0x.063	31.2	4.00	14.75	125.-	460.-
" Sump 12.5x19.0x2.5x.063	37.4	14.75	11.00	552.-	412.-
Uplift. 29.5x22.5x13.0x.063	-543.6	11.25	14.75	-6116.-	-8018.-
	351.3 ^K			4277. ^{1K}	5134. ^{1K}

$e_y = \frac{5134}{351} = 14.63$ $e_x = \frac{4277}{351} = 12.19$
 $e_y = 12.19 - 11.25 = .94'$ $e_x = 14.75 - 14.63 = .12'$

$S.P.P. = P/A \pm \frac{P e_y c}{I_{xx}} \pm \frac{P e_x c}{I_{yy}}$

1. = $\frac{351}{664} - \frac{351 \times .94 \times 14.75}{28000} + \frac{351 \times .12 \times 14.75}{48135} = .53 - .14 + .01 = .40 \text{ K/sf}$

2. = $.53 + .14 + .01 = .68 \text{ K/sf}$

3. = $.53 + .14 - .01 = .66 \text{ K/sf}$

4. = $.53 - .14 - .01 = .38 \text{ K/sf}$

27 Sept 49

CORPS OF ENGINEERS, U. S. ARMY

SUBJECT ST JOHNSBURY

COMPUTATION PUMPING STATION

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Case II Concrete, Uplift from El. 550.-
Water in Bypass, Jump & Intake to El. 516.0

Item	WT. L	YAPMA	Acmm	MA-x/16	MY-x/16
Forward	812.1			9507.	11925.
Water Bypass 6.0x12.5x7.5x.063	35.4	14.75	2500	522.-	885.-
" Intake 27.5x6.0x7.5x.063	80.-	4.00	14.75	320.-	1130.
" Jump 12.5x19.0x7.0x.063	104.7	14.75	11.00	1544.-	1152
Uplift 29.5x22.5x13.0x.063	-543.6	11.25	14.75	-6116.-	-8018.-

$$\frac{\sum M_y}{\sum V} = \frac{7124}{489} = 14.57'$$

$$\frac{\sum M_x}{\sum V} = \frac{5777}{489} = 11.81'$$

$$e_y = 11.81 - 11.25 = .56'$$

$$e_x = 14.75 - 14.57 = .18'$$

$$S.I.P. = P/A \pm \frac{P e_y}{I_{xx}} \pm \frac{P e_x}{I_{yy}}$$

$$1. = \frac{489}{664} - \frac{489 \times .56 \times 11.25}{28,070} + \frac{489 \times .18 \times 14.75}{48,135} = .74 - .11 + .03 = .67 \text{ 1/2}$$

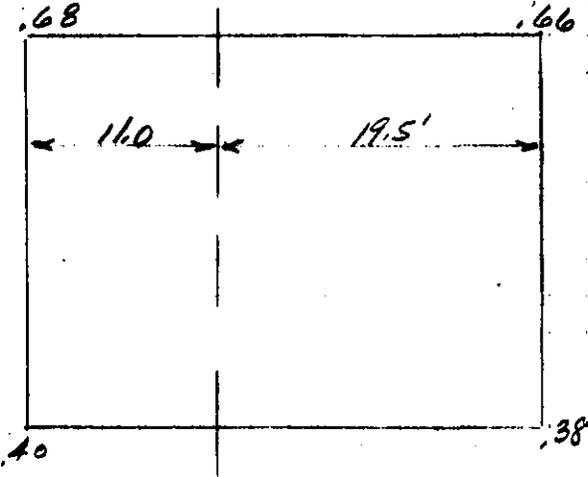
$$2. = .74 + .11 + .03 = .88 \text{ 1/2}$$

$$3. = .74 + .11 - .03 = .82 \text{ 1/2}$$

$$4. = .74 - .11 - .03 = .60 \text{ 1/2}$$

SUBJECT ST JOHNSBURY
COMPUTATION PUMPING STATION
COMPUTED BY EPG CHECKED BY WJM DATE OCT 1966

Location of Design Section

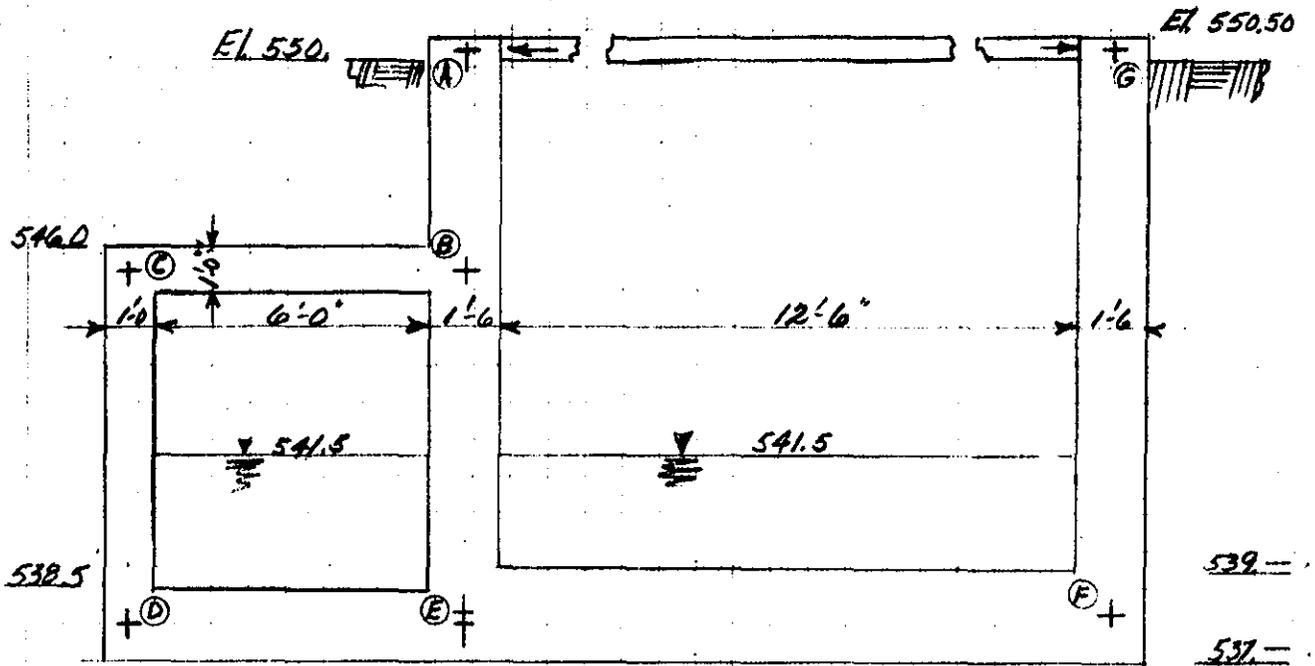


$$\begin{array}{r} .68 \\ \underline{.66} \\ .02 \end{array} \quad \frac{.02 \times 19.5}{29.5} = .01$$

$$\begin{array}{r} .40 \\ \underline{.38} \\ .02 \end{array} \quad \frac{.02 \times 19.5}{29.5} = .01$$

$$\begin{array}{r} .67 \\ \underline{.39} \\ 1.06 \end{array} \quad \frac{1}{1.06} = .94 \quad \text{Arc S.D.P.}$$

SUBJECT ST. JOHNSBURY
COMPUTATION PUMPING STATION
COMPUTED BY EPG CHECKED BY EGM DATE OCT 1966



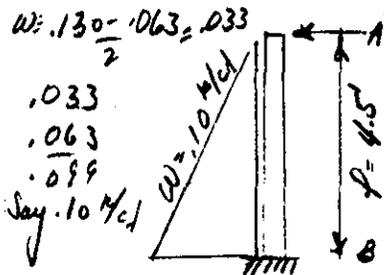
Scale $1/4" = 1'-0"$

Member	Length ft	Length in	d in	d^3 in ³	d^3/L	k
A-B	4.5'	54"	18	5832.-	108.-	5.7
B-C	7.25'	87"	12	1728.-	20.-	1.1
C-D	7.75'	93"	12	1728.-	19.-	1.0
D-E	7.25'	87"	18	5832.-	67.-	3.5
B-E	7.75'	93"	18	5832.-	63.-	3.3
E-F	14.06'	168"	24	13824.-	82.-	4.3
F-G	12.0'	144"	18	5832.-	40.-	2.1

SUBJECT ST JOHNS BURY
COMPUTATION PUMPING STATION
COMPUTED BY E. P. G CHECKED BY W. M. DATE OCT 1966

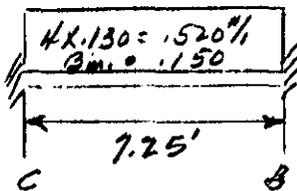
Member loadings & F.E.M.s.

Say all members are loaded from E to E.
Neglect lateral loading from interior water loads.



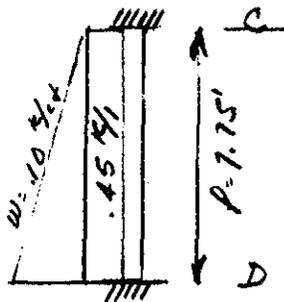
$$M_{B-A} = \frac{1}{15} \times .10 \times 4.5 \times 4.5^2 = .61 \text{ 'k}$$

$$M_{A-B} = .6 \text{ 'k}$$



$$M_{B-C} = \frac{1}{12} WL^2 = \frac{1}{12} \times .670 \times 7.25^2 = 2.9 \text{ 'k}$$

$$M_{C-B} = 2.9 \text{ 'k}$$

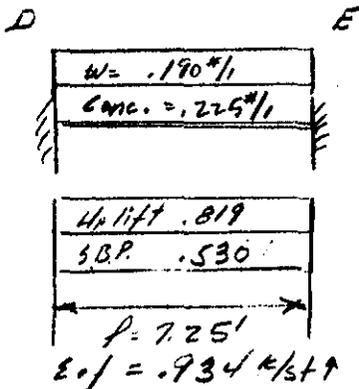


$$M_{C-D} = \frac{1}{12} WL^2 = \frac{1}{12} \times .450 \times 7.75^2 = 2.25 \text{ 'k}$$

$$M_{D-C} = \frac{1}{20} WL^2 = \frac{1}{20} \times .10 \times 7.75^3 = \frac{1.55}{4} = 3.80 \text{ 'k}$$

$$M_{D-C} = \frac{1}{12} WL^2 = 2.25 \text{ 'k}$$

$$M_{B-C} = \frac{1}{20} WL^2 = \frac{1}{20} \times .10 \times 7.75^3 = \frac{2.73}{6} = 4.58$$

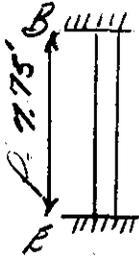


$$M_{D-E} = \frac{1}{12} WL^2 = \frac{1}{12} \times .934 \times 7.25^2 = 4.1 \text{ 'k}$$

$$M_{E-D} = 4.1 \text{ 'k}$$

SUBJECT ST JOHNS BURY
COMPUTATION PUMPING STATION
COMPUTED BY E.P.G. CHECKED BY AGM DATE Oct 1966

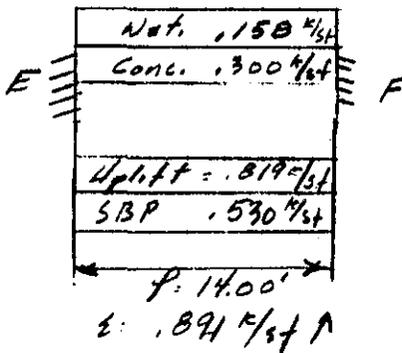
Member Loadings & FEM's Cont.



No differential loading.

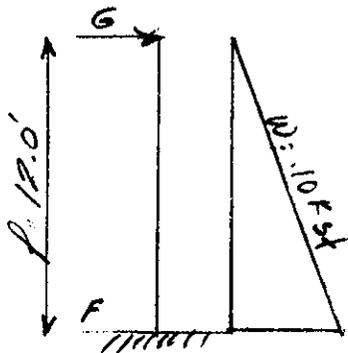
$$FEM_{B-E} = 0$$

$$FEM_{E-B} = 0$$



$$M_{E-F} = \frac{1}{12} W L^2 = \frac{1}{12} \times .811 \times 14.0^2 = 14.6 \text{ k}$$

$$M_{F-E} = 14.6 \text{ k}$$

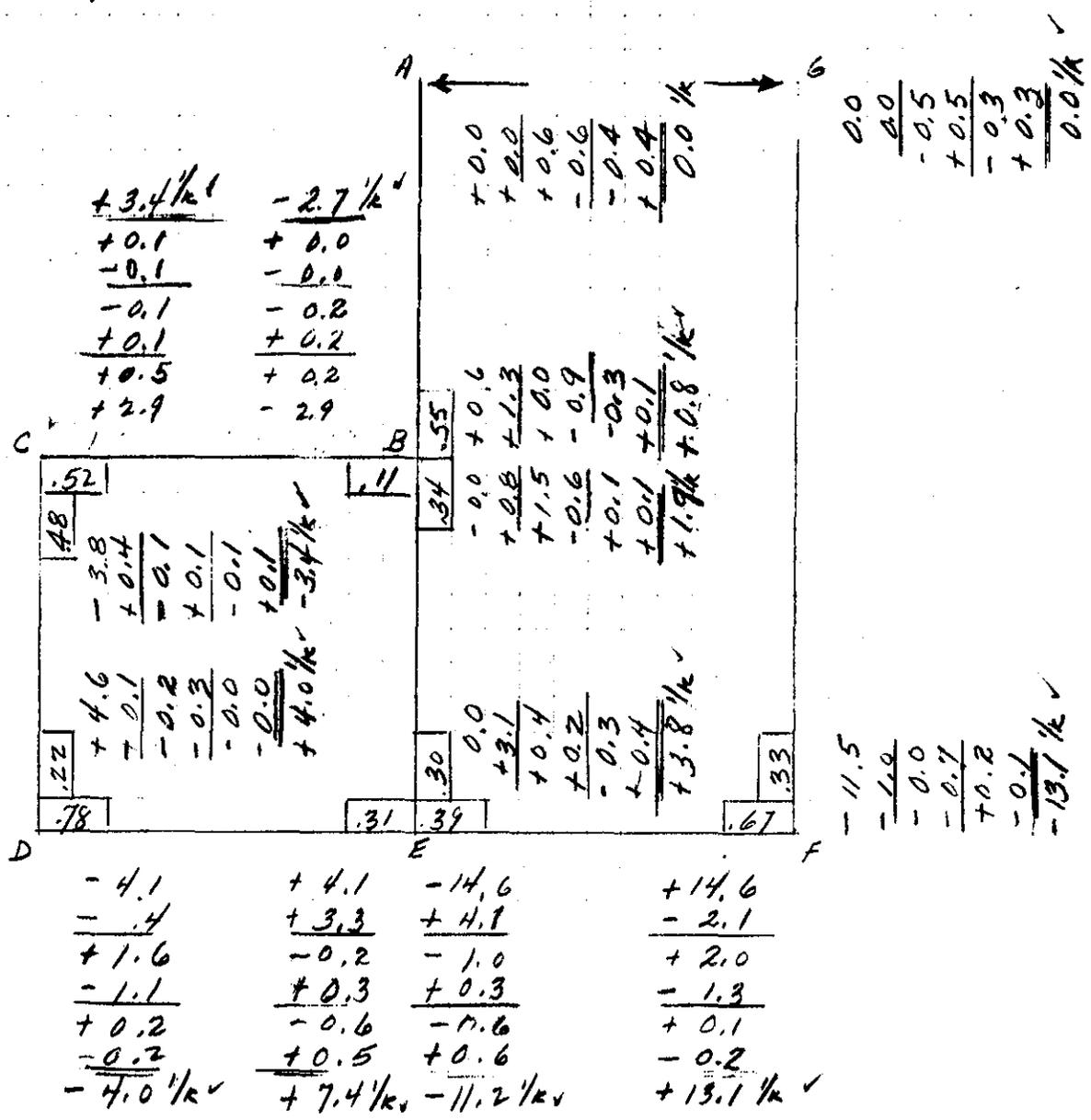


$$M_{F-G} = \frac{1}{15} \times .10 \times 12 \times 12^2 = 11.5 \text{ k}$$

SUBJECT ST JOHNSBURY

COMPUTATION PUMPING STATION

COMPUTED BY EPG CHECKED BY 420M DATE Oct 1966

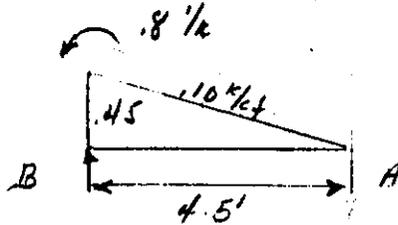


Dist Factors

Joint B		c	d	e	f
5.7	5.7/10.3 = .55	1.0	1.0 = .22	3.5	3.5 = .31
1.1	1.1/10.3 = .11	2.1	4.5	3.3	11.1
3.5	3.5/10.3 = .34	4.1	3.5 = .78	4.3	3.3 = .30
10.3		2.1	4.5	11.1	11.1
				4.3/11.1 = .39	2.1/6.4 = .37

SUBJECT ST JOHNSBURY
COMPUTATION PUMPING STATION
COMPUTED BY E.P.G. CHECKED BY lym DATE Oct. 1966

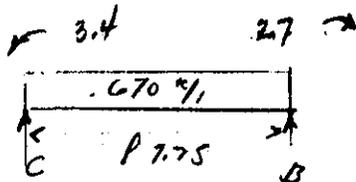
Design of Members



$$R_B = \frac{.45 \times 4.5 \times \frac{2}{3}}{2} + \frac{.800}{4.5} = .680 + .180 = .860 \text{ k}$$

$$R_A = \frac{.45 \times 4.5 \times \frac{1}{3}}{2} - \frac{.700}{4.5} = .340 - .150 = .190 \text{ k}$$

+ M not a factor.

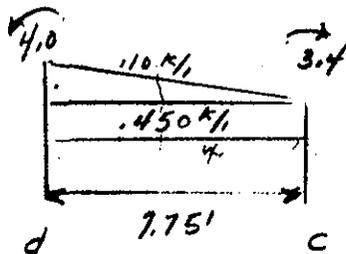


$$R_C = .670 \times 7.75 + \frac{.9}{7.75} = 2.44 + .100 = 2.54 \text{ k}$$

$$R_B = 2.44 - .1 = 2.34 \text{ k}$$

$$V=0 @ 2.5 - .670 \times x = 3.8'$$

$$EM = 2.5 \times 3.8 - \frac{.670 \times 3.8^2}{2} - 3.4 = 9.5 - 4.8 - 3.4 = 1.3 \text{ k}$$



$$R_C = \frac{.450 \times 7.75}{2} + \frac{7.75 \times .70}{7.75} = 1.74 + 1.0 - .080 = 2.70 \text{ k}$$

$$R_D = 1.74 + 2.0 + .080 = 3.8 \text{ k}$$

$$V=0 = 2.70 - .450 \times x - \frac{1.7(2.8x)}{3 \times 2 \times 7.75} = 0$$

$$2.70 = .45x + \frac{.78x^2}{47.5}$$

$$x^2 + 27.41x = 178.75$$

$$x = 4.07' \text{ from } R_C$$

SUBJECT ST JOHNSBURY

COMPUTATION PUMPING STATION

COMPUTED BY E. P. G.

CHECKED BY W. M.

DATE OCT 1966

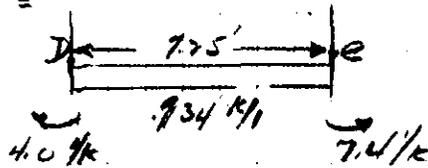
Design of Members Cont.

d-c Cont.

$$\Sigma m @ V=0 \quad 4.07 \times 2.70 - 1.450 \times \frac{4.07^2}{2} - \frac{4.07 \times 4.1}{2 \times 3} - 3.4 =$$

$$= 11 - 3.7 - 1.1 - 3.4 = 2.8'k$$

D-c =



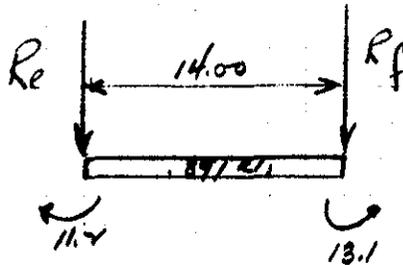
$$R_d = + \frac{9.34 \times 7.75}{2} - \frac{3.4}{7.75} = 0$$

$$R_d = 3.38 - .47 = 2.91'k$$

$$R_e = 3.38 + .47 = 3.85'k$$

$$V=0 @ 2.91 - .934' \quad x = 3.1'$$

$$\Sigma m @ 3.1' \text{ from } d: \quad 2.91 \times 3.1 - \frac{3.1^2}{2} \times .934 - 4.0 = 9.0 - 4.5 - 4.0 = .5'k$$



$$R_e = \frac{.891 \times 14.0}{2} - \frac{1.9}{14.0} = 6.25 - .14 = 6.11'k$$

$$R_f = 6.25 + .14 = 6.39'k$$

$$V=0 @ 6.11 - .891'x$$

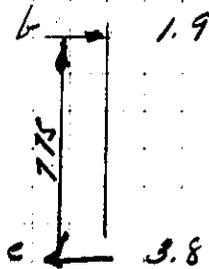
$$x = 6.85' \text{ from } R_e$$

$$\Sigma m @ V=0 \quad 6.11 \times 6.85 - .891 \times \frac{6.85^2}{2} - 11.4 =$$

$$= 41.8 - 20.9 - 11.4 = 9.7'k$$

SUBJECT ST JOHNSBURY
COMPUTATION PUMPING STATION
COMPUTED BY E.P.G. CHECKED BY KJM DATE Oct 1966

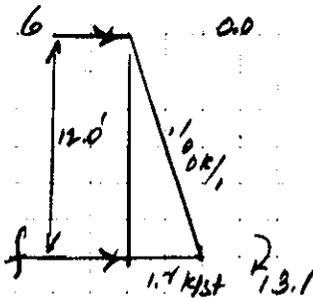
Design of Members Cont.



$$R_d = \frac{57}{7.75} = .74 \rightarrow$$

$$R_c = .74 \leftarrow$$

No differential loading: No Pos. M.



$$\sum M_R = 17.0 R_f - 1.7 \times \frac{17^2}{2 \times 3} - 13.1 =$$

$$R_f = 4.8 + 1.1 = 5.9 \text{ k}$$

$$R_g = 4.8 - 1.1 = 4.7 \text{ k}$$

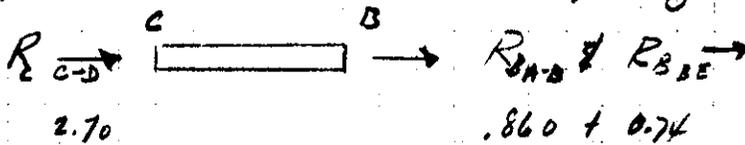
$$x = 0 @ 4.7 - .1 \frac{4^2}{2} =$$

$$x^2 = \frac{4.7 \times 2}{.1} = \frac{9.4}{.1} = 94$$

$$x = 9.7' = x = 0 \checkmark$$

$$\sum M \frac{4.7 \times 9.7 - .1 \times 9.7^3}{6} = 45.6 - 15.2 = 30.4 \text{ 'k}$$

Check Member C-B as Deep Horizontal Beam. to take



unbalanced horizontal forces @ Joint "B"

$$M = \frac{1}{8} w L^2 = \frac{1}{8} \times 330 \times 20.5^2 = 173 \text{ 'k}$$

$$A_s = \frac{173 \times .6}{.89 \times 98} = 1.19 \text{ si } A_s$$

$$A_s = \frac{173 \times .6}{.89 \times 93} = 1.26 \text{ si reqd.}$$

$$4 \# 5 = 1.24 \text{ si ok.}$$

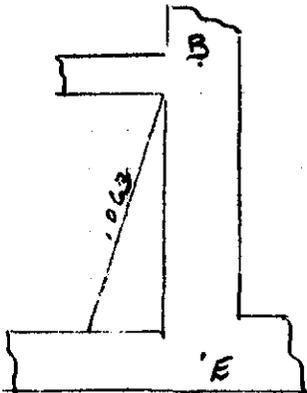
This slab will have reinf. each way on both faces so will be sufficient.

SUBJECT St. JOHNSBURY
COMPUTATION PUMPING STATION
COMPUTED BY E. P. G. CHECKED BY EGM DATE Oct. 1966

Summary of Members

	M _k	V _k	N _k	t	Cover	d"	As read.	v	w
A-B	- - + - - .8	.16 - .86	-	18"	3"	15"	Min " "	ok	ok
B-C	+ 2.7 + 1.3 - 3.4	2.34 - 2.54	T .86 C 2.7	12"	3"	9"	Min. . .25	18 psi	ok
C-D	+ 3.4 + 2.8 - 4.0	2.7 - 3.8	C 2.54 C 3.85	12"	3"	9"	Min. . .30	ok 26 psi	117 psi ok
D-E	+ 4.0 + .5 - 7.4	2.9 - 3.85	C 3.85	18"	4"	14"	Min min. .36	ok	ok
B-E	- 1.9 - - 3.8	.74 - .74	2.3 C 9.9	18"	3"	15"	Min Min Min	ok	ok
E-F	+ 11.2 + 9.7 - 13.1	6.1 - 6.4	- C 5.9	24"	4"	20"	.38 .33 .44	ok ok 22 psi	157 ok
F-G	+ 13.1 80.4 -	5.9 - 4.7	C 7.5	18"	3"	15"	.59 1.37 ¹⁴ -	ok 27 psi	

Check Member B-E for conduit full, Sump Empty



$$M_{bB} = \frac{1}{20} wL^3 = \frac{1}{20} \times 1.063 \times 7.75^3 = 1.5/k$$

min. As, ok.

Positive Mb minor.

APPENDIX F
REAL ESTATE

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4	PROJECT AND SITE DESCRIPTION	F-1
5	UTILITIES	F-2
6	PRESENT AND HIGHEST AND BEST USE	F-2
7	ZONING	F-2
8	RELOCATIONS	F-2
9	BORROW REQUIREMENTS	F-3
10	RECOMMENDED ESTATES TO BE ACQUIRED	F-3
11	SEVERANCE DAMAGES	F-3
12	ACQUISITION COSTS	F-4
13	ASSUMPTIONS AND LIMITING CONDITIONS	F-4
14	EVALUATION	F-4
	a. Permanent Easements	F-5
	b. Temporary Easements	F-5
	c. Land Under Water	F-5
15	COST SUMMARY	F-6

APPENDIX F

REAL ESTATE

1. PURPOSE

The purpose of this report is to describe the properties involved and to estimate the costs of real estate interests required for the proposed project as of 15 September 1966.

2. LOCATION

It is proposed to locate the subject project along the banks of the Passumpsic and Sleepers Rivers in the Town of St. Johnsbury, County of Caledonia, State of Vermont.

3. AREA DESCRIPTION

The Town of St. Johnsbury is situated in northeastern Vermont and covers an area of approximately 21,076 acres. The Town's estimated population is 8,869 of which 6,809 live in the highly developed area of St. Johnsbury Village. Excellent shopping and service facilities are available in the village. Access is very good with U.S. Routes 5 and 2 passing through the Town. The new U.S. Routes 91 and 93 which are presently under construction will also traverse and serve the Town. Bus service between other towns and cities is provided by the Vermont Transit Company. Rail service is supplied by the St. Johnsbury and Lamoille County, Canadian Pacific and Maine Central Railroads. All utilities are available to most areas within the village limits.

4. PROJECT AND SITE DESCRIPTION

The proposed project consists of the construction of partial stone and earthen dikes, bin type retaining walls, the improvement of an existing dike and the relocation of the channel of the Sleepers River for a distance of about 500 feet, a pumping station and railroad gate. The proposed construction will extend a distance of approximately 2,800 feet along or near the banks of the Passumpsic and Sleepers Rivers. The top of the proposed dike is at elevation 561' m.s.l.

The site of the proposed project is in a developed industrial area situated in St. Johnsbury Village.

The construction will extend from a point at high ground on the southeasterly side of Bay Street, turn and run south along the banks of the Passumpsic River and turn again at the confluence of the Passumpsic and Sleepers Rivers and runs westerly along the Sleepers River to high ground on the easterly side of the U.S. Route 5. The project will traverse the Canadian Pacific Railroad line at which point a gate structure will be constructed. The proposed alignment will traverse lands at the rear of the large Purina Company's grain building and a recently constructed municipal sewage disposal plant. Access road ramp will be constructed over the dike to permit access to a grain hopper situated at the rear of the Purina Company building which will be allowed to remain unprotected. A strip of land will also be required along the side and front of the Purina Company's building for construction of a drain line.

The total area required for project purposes consists of approximately 14.93 acres, of which approximately 7.73 acres will be required under permanent easements, 5.85 acres will be needed under temporary easements for construction, and 1.35 acres lies under water. No buildings are located within the taking area.

5. UTILITIES

Town water, sewerage, electric power and telephone facilities are available within the project area.

6. PRESENT AND HIGHEST AND BEST USE

The highest and best use of the subject land is considered to be for industrial purposes which is the present use of the developed areas.

7. ZONING

The subject land lies within an industrial zone. There are no delineated minimum area requirements.

8. RELOCATIONS

As previously mentioned, the existing gravel access road to the grain hopper at the rear of the Purina Company building will be raised to permit access over the dike. A gasoline pump with an underground storage tank situated at a point along this road will also be raised or relocated during construction. It is anticipated that existing utility lines or poles within the construction area will be raised in place

or relocated within the taking area where required, and therefore, no additional land is provided for this purpose.

9. BORROW REQUIREMENTS

It is anticipated that borrow requirements will be furnished by the contractor, and therefore, no land is included for this purpose.

10. RECOMMENDED ESTATES TO BE ACQUIRED

Partial takings from an estimated five properties will be required for the project's construction in addition to land presently owned by the Town of St. Johnsbury. It is recommended that real estate interests be acquired under easement, in lieu of fee, although permanent easement values for land required for major construction, such as dikes, walls and channel relocation, will approximate the fee value due to the great reduction in utility.

Acquisition of fee estates of this land would sever legal access to approximately 6.5 acres of land and the grain hopper thereby necessitating the purchase of this additional property in fee at an estimated additional cost of \$60,000 based on preliminary investigations. Acquisition of the strip of land required for the construction of the drain line must be under a permanent easement as the acquisition in fee would completely sever legal access to the Purina Company's main plant and related improvements. Sound real estate practice indicates that costs will be greatly reduced by the taking of easement interests, as access to remainders will be left with underlying fee ownerships and the payment of severance damages will be far less than if fee interests were acquired.

11. SEVERANCE DAMAGES

Severance damages have been estimated on the basis of "Before and After" appraisal methods and reflect an estimate of value losses incurred by remainders as a result of partial takings. Approximately 6.5 acres of land owned by the Purina Company will be left outside of the protected area after construction of the dike. Although an access ramp will be provided over the dike this land will suffer a loss of value due to its more restrictive access and the limiting of its utility due to its being severed from the main portion of the property by the construction of the dike. Damages to this area are estimated at about 50% of the fair market value or about \$8,000 rounded. Consideration is also given to the fact that both permanent and temporary easements will be acquired through

the Purina Company's paved parking lot, for construction of the drain line and work areas. This area will be repaved after project construction thereby returning the land to its present improved condition. However, damages will be sustained by the loss of the use of a large portion of the parking area during the two-year construction period and will necessitate the preparation of a temporary parking area on adjacent land. Damages due to this temporary loss are estimated at \$2,000. The total severance damages, therefore, are estimated at \$10,000.

12. ACQUISITION COSTS

Local interests will provide all lands, easements and rights-of-way necessary for construction of the project. Based on experience of this office, costs of acquisition, which include mapping, survey, legal descriptions, title work, appraisals, negotiations, closings and administrative costs for condemnations are estimated at \$3,000 for the required five tracts.

13. ASSUMPTIONS AND LIMITING CONDITIONS

It is assumed that temporary provisions will be made during construction, to replace heavily traveled gravel access roads to the grain hopper at the rear of the Purina Company building, to a powerhouse and nine silos at the front of the building, thereby eliminating severance damages caused by temporary loss of access. It is also assumed that area required under temporary easements will be restored to reasonable present conditions following construction of the project. This report is predicated upon these assumptions.

14. EVALUATION

A search was made in the St. Johnsbury area to obtain industrial sales' data. The local assessor, town manager and other knowledgeable persons were interviewed to obtain record data and value estimates. Knowledge of the real estate market was obtained from this survey and analysis which forms the basis for estimating the real estate costs for the subject project.

It is the writer's opinion that permanent easements for dikes, walls and channel relocation will approximate the fee value of the required land due to the great reduction in utility caused by the project. Permanent easements for the underground drain line will limit the utility of the affected land by prohibiting the possible future construction of major

improvements such as buildings, however, the land will still have utility for parking or access roadways as presently used, and therefore, the easement values on this land will be estimated at 50% of its fair market value.

Temporary easement values are predicated upon a fair return of invested capital and real estate tax expenses for a 2-year duration, and is estimated at 10% of fair market value per annum.

The estimated easement values for the subject project are as follows:

a. Permanent Easements

6.19 acres @ \$2500. P/A	\$15,475.
0.28 " @ 2500. P/A x 50%	350.
<u>1.26 " @ 100. P/A</u>	<u>126.</u>
7.73 acres	\$15,951.

b. Temporary Easements

4.98 acres @ \$2500. P/A x 10% x 2	\$ 2,490.
<u>0.87 " @ 100. P/A x 10% x 2</u>	<u>17.</u>
5.85 acres	2,507.

c. Land Under Water

1.35 acres	-0-
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<u>TOTAL EASEMENT VALUES</u>	<u>\$18,458.</u>
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Rounded to:	\$18,500.
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15. COST SUMMARY

* Land	\$18,500.
Severance Damages	10,000.
Acquisition Costs	3,000.
Contingencies (15% of \$31,500.)	<u>4,725.</u>
TOTAL REAL ESTATE COSTS	\$36,225.
	Rounded to: \$36,000.

* Total includes approximately 1.4 acres of land presently owned by the Town of St. Johnsbury. The exclusion of the estimated value of this land would reduce the total Real Estate Costs to an estimated \$33,000.